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ORIGINAL ARTICLES.

I.—On the Pleistocene Ossiferous Deposits of the Balearic Islands.

By Dorothea M. A. Bate.

(PLATE XXV.)

I. Mallorca.

LIKE so many of the islands of the Mediterranean the Balearic group has yielded interesting remains of an extinct Pleistocene fauna. These have been discovered in cave breccias and in fissures of which a brief description may be of interest.

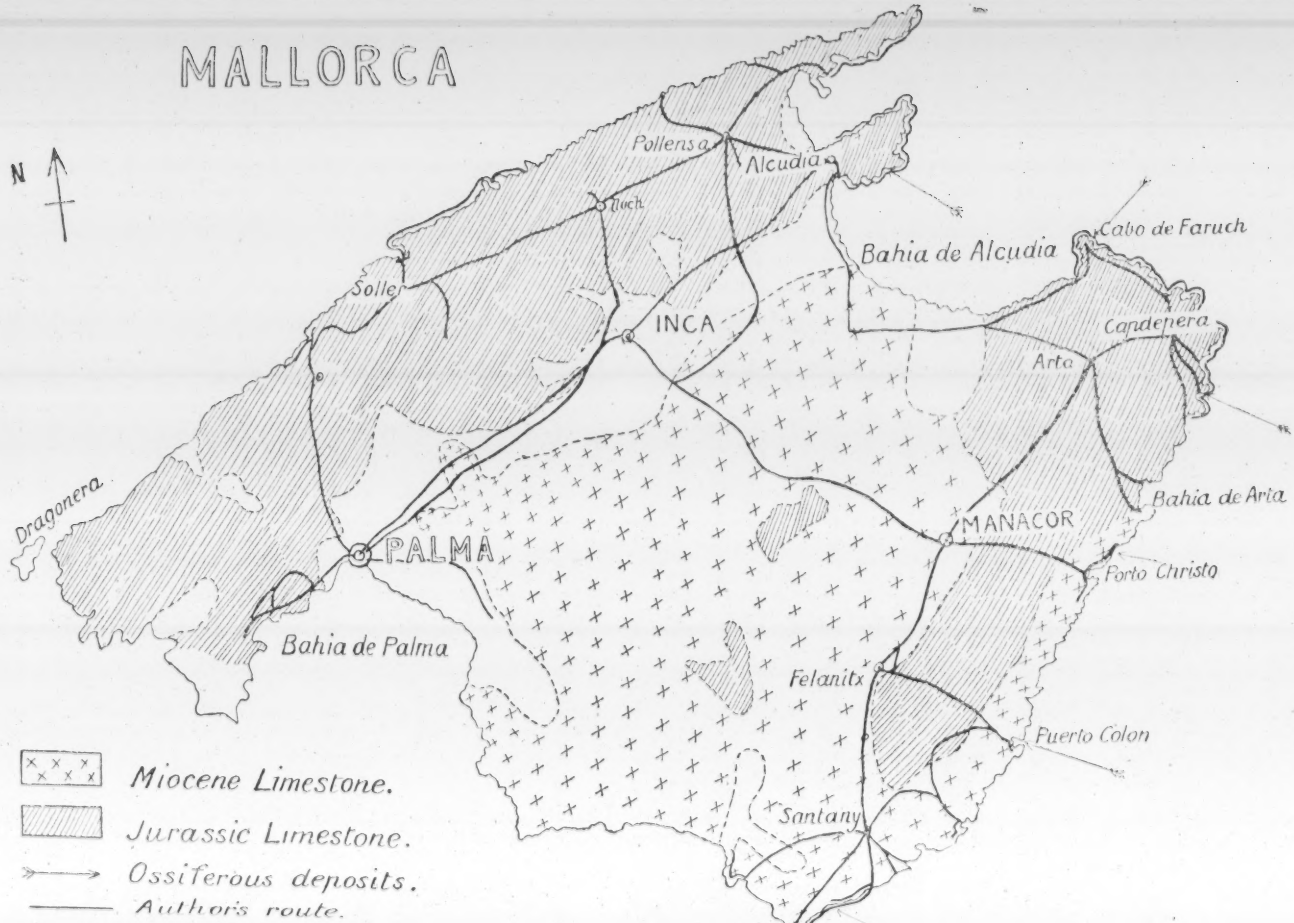
Previous to 1909 the only record of the occurrence of any Pleistocene mammalian remains in the Balearic Islands was, I believe, that of De la Marmora,[1] who mentioned indications of a bone breccia in the hill of Belver, near Palma, where he observed a bone which appeared to be that of a *Lagomys* or a rabbit. Since then, as the result of three short visits undertaken by the writer, a quantity of ossiferous remains have been obtained from the caves and fissures of Mallorca and Menorca. It may be mentioned that I failed to locate the breccia recorded near Belver.

Mallorca (Text-fig. 1) is the largest island of the group, in shape an oblique square, or trapezoid, containing an area of 430 square miles. Its geological formation has been exhaustively studied by Hermite [2] and others, and it will only be necessary here to state briefly that it is almost entirely composed of Jurassic and Miocene Limestones. The extent of either is very noticeably defined in the general appearance and elevation of the country, the former being invariably the more rugged and mountainous. Palma, the capital and largest coast town, lies on the edge of a strip of diluvial soil which stretches across the island to the marsh lands of the Albufera on the Bay of Alcudia in the north-east. Other formations, including some of Lower Eocene age, but of still smaller extent are also to be seen, but have no immediate bearing on the subject in hand.

The Jurassic Limestone occurs in two isolated masses. The larger of these forms the chief mountain chain, which runs in a north-easterly direction from the Islet of Dragonera to Cabo Formenton; the distance between these two points represents the greatest width of the island. This range rises to a height of 1,445 metres and exercises a most beneficial influence on the climate of the fertile

[1] "Observations géologiques sur les deux Iles Baleares": Mem. Accad. Sci., Torino, sér. I, vol. xxxvii, p. 59, 1855.

[2] *Etudes géologiques sur les Iles Baléares*, Paris, 1879.


MALLORCA
N
Pollensa
Alcudia
Lluch
Bahia de Alcudia
Cabo de Faruch
Soller
INCA
Candepera
Arta
Dragonera
PALMA
MANACOR
Bahia de Arta
Porto Christo
Bahia de Palma
Felanitx
Puerto Colon
Santany
Miocene Limestone.
Jurassic Limestone.
Ossiferous deposits.
Author's route.

plains, which, by its means, are protected from the winds that sweep almost continuously across the adjacent island of Menorca. The smaller of the two Jurassic masses occupies the eastern corner of the island from the Bay of Alcudia to the Bay of Arta, where this formation leaves the coast and continues as a narrow strip to a little beyond the village of Concos. A few small outcrops of this rock are also met with in the central plain. This central portion of the island is composed of a Miocene Limestone which extends to the southernmost point, Cabo Salinas, from which it forms the coast-line for a considerable distance in either direction.

Numberless caves occur in each of the above-mentioned limestone formations, and Mallorca is justly celebrated for its wonderful caverns, which often extend over very large areas. Many have been exhaustively explored by M. E. A. Martel, who has published interesting accounts of his investigations in Spelunca. It will suffice here to mention that the most important and best known are those of Arta and the Drach, both situated on the coast and in the Jurassic and Miocene Limestones respectively. The latter contains a considerable amount of fresh water, and in 1904 the researches of M. Racovitza were rewarded by the discovery of an aquatic blind Isopod ascribed to a new genus[1] as well as other representatives of an interesting fauna. Other grottoes of considerable size are those of Pirata, one at Orient in the northern range, one discovered recently near Cabo de Menorca, and doubtless many unknown to more than local fame. Most of the above and many other large caves were visited, but in none were indications of an ossiferous deposit discovered.

Six Pleistocene ossiferous deposits were discovered in Mallorca, of which the following is a list:—

1. Near Porto Christo.
2. Cave at harbour mouth of Puerto Colon.
3. Cala Figuereta, near Santañy.
4. Cave, Fuente de la Cala, near Capdepera.
5. Cuevas de los Colombs, Cap Faruch.
6. Cave near Cabo de Menorca, Alcudia.

The first three were situated in sea cliffs of much worn Miocene Limestone and were very fragmentary, yielding no specimens worth preserving. No. 3 was represented by but a single limb-bone, probably that of *Myotragus*, attached to the rocks only just out of the water in calm weather. No. 1 is at the summit of the cliffs a few yards from their edge; what is left of the bone breccia lies between layers of stalagmite and measured 6 by 2 or 3 feet. An isolated bone a few yards distant indicated the originally greater extent of the deposit. Its appearance suggests that it was formed in a fissure, but in this connexion it may be worth recording that near the cliff edge for a distance of about half a mile from this spot there are innumerable traces of the bases of stalagmites and of stalagmitic layers. These may extend uninterruptedly for a hundred yards or more, and suggest the former existence of a system of caverns and galleries of vast extent.

[1] Bull. Soc. Zool. France, tom. xxx, No. 4, p. 72 et seq., Juillet, 1905.

The three ossiferous deposits given last in the above list were contained in coast caves in the Jurassic Limestone. Owing to this protection these were more extensive and better preserved than those described above.

No. 4 is locally known as the Cueva de la Barxa. An entrance is effected through a rent in the roof, and a drop of 7 or 8 feet gives access to a chamber about 20 yards long by 5 wide; both roof and rock-strewn floor slope down to what was the original entrance and where the sea now breaks through and ordinarily fills perhaps half the floor space with quiet pools. At the inner and upper end a small opening leads to the main portion of the cavern. This contains stalactites and a stalagmitic flooring partially covered with fresh water and with a few Recent bones already attached to its surface by a coating of lime deposit.

The mammalian remains were obtained from the chamber first entered. Here the whole floor had formerly been covered by an ossiferous deposit 6½ feet thick. This had been subsequently almost entirely demolished, leaving small isolated patches of bone breccia in crevices in the walls. The full force of the waves can have barely reached the extreme length of this chamber, for a small part of the ossiferous flooring remained at its inner end immediately below the opening leading to the larger cavern. A section of this was exposed, showing it to be at this point about 3½ feet wide by 3 deep. It rested on stalagmite, and its upper surface was also protected by an uneven crust with a minimum thickness of 4 inches, which was greatly exceeded in places. The face of the section was also partially covered by stalagmite an inch thick, which must have formed subsequently to the general destruction of the flooring. The most important remains obtained here were those of *Myotragus balearicus*, including the type-specimens.[1] Numerous land shells also occurred, some with traces of colour still persisting. These were kindly identified by the late Rev. R. Ashington Bullen[2] as *Vitrea lentiformis*, *Otala balearica*, *Helicella myelli*, and *Tudorella ferruginea*, species still extant in the islands.

The promontory forming the northern shore of the Bay of Alcudia is composed of Jurassic Limestone. In the cliffs near Cabo de Menorca, and about 25 feet above the sea, were two cleft-like grottoes which might formerly have been neighbouring chambers of one large cavern. The eastern half, No. 6 of the list, was only 3 feet high by 10 or 12 wide at its entrance; the floor was of rough, uneven rock, and there were a few traces of ossiferous remains. The most important of these was to one side, where a section was exposed of a deposit of reddish earth two yards in extent and surmounted by two thin layers of stalagmite. The specimens contained in this earth were thickly coated by a limey concretion, which also massed

[1] "A new Artiodactyle from Majorca, *Myotragus Balearicus*, gen. et sp. nov.," by D. M. A. Bate: GEOL. MAG., 1909, pp. 385–8. See also Reports and Proceedings, Royal Society, June 18, 1914, "Description of the Skull and Skeleton of a Rupicaprine Antelope, *Myotragus balearicus* (Bate)," by Dr. C. W. Andrews, F.R.S.: GEOL. MAG., reprinted *infra*, p. 378.

[2] Proc. Malac. Soc., vol. ix, pt. ii, June, 1910, pp. 118–22.

a number together. This condition of the bones in a soft matrix pointed to their not being in their original place of deposition.

In the extreme east of Mallorca lies a considerable tract of uninhabited and mountainous country. It is composed of a Jurassic Limestone and culminates in Cabo de Faruch, which forms the eastern horn of the Bay of Alcudia. A little to the south-east of this a rocky point jutting into the sea has its face pierced by about six or seven grottoes and cavities known as Cuevas de los Colombs, No. 5 of the list. The lowest of these, shown in Pl. XXV, Fig. 1, was not more than 15 feet above the sea, and the series of openings continued in a steeply ascending line for a distance of 50 or 80 yards. The floors of the uppermost ones were covered with dry sand, but it was only in the lower that any ossiferous remains were observed. It can be seen from the accompanying photograph that the cliff face had evidently broken away, leaving the caves exposed to the action of the waves. In winter these break in with great violence and have effectually destroyed the stalagmitic and ossiferous flooring formerly present. Fragments of this were found only in holes and crevices protected from the full force of the breakers.

The highest point at which mammalian remains occurred was in the only portion left of the main cave floor deposit. A section showed this to consist of a layer of earth and some bones 4 to 5 feet thick surmounted by one of red earth a foot or more in depth; its surface was protected by 4 to 6 inches of stalagmitic crust. Almost all the remains obtained were procured from two 'pockets' in the inner wall of one of the chambers. The openings to these were small and insignificant and gave no indication of the enclosed deposits. On the entrance to one being enlarged, it was found to run in for a distance of slightly over 6 feet, and was filled almost to its roof by a deposit of mammalian remains in a wet red earth covered by stalagmite $\frac{3}{4}$ of an inch thick. The second 'pocket' was entirely filled with a very similar deposit, though here bones of birds and rodents were more plentiful, especially in the upper part of the cavity. The remains were chiefly those of *Myotragus*; many scattered fragments of pine charcoal[1] occurred and several pharynges of the wrasse with their rows of teeth were also obtained.

Two days were spent on the small island of Cabrera off the south coast of Mallorca, where several caves were visited, but no ossiferous remains were encountered.

II. Menorca.

A third visit to the Balearic Islands was made possible in the autumn of 1911 by the receipt of a grant from the Trustees of the Percy Sladen Memorial Fund. On this occasion the primary object was to search for Pleistocene mammalian deposits in the smaller islands of Menorca and Ibiza, from which no ossiferous remains had been previously reported.

Ten days were first spent in Ibiza, which is a hilly island with a greatest length of 41 and a breadth of 20 kilometres. Many caves were visited, but no trace of any ossiferous deposit was discovered here.

[1] These were kindly examined and identified for me by Miss E. Loraine Smith.

Menorca (Text-fig. 2) is the most easterly of the group and lies 27 miles from Mallorca, from which it differs greatly in many important respects. It has an extreme length of 49 kilometres with a greatest width of 21 kilometres. The coastline is said to measure over 200 kilometres. An imaginary line may be drawn from a point on the coast some miles to the north-east of Cabo Bajoli throughout the length of the island to Mahon in the south-east. To the north and east of this lies a low, broken country of divers formations in isolated strips. These include several outcrops of Jurassic Limestone, one of which forms the highest point of the island, Monte Toro, which attains a height of a little over 1,100 feet. To the west and south of this imaginary line the island is entirely composed of Miocene Limestone. This forms a flat-topped plateau

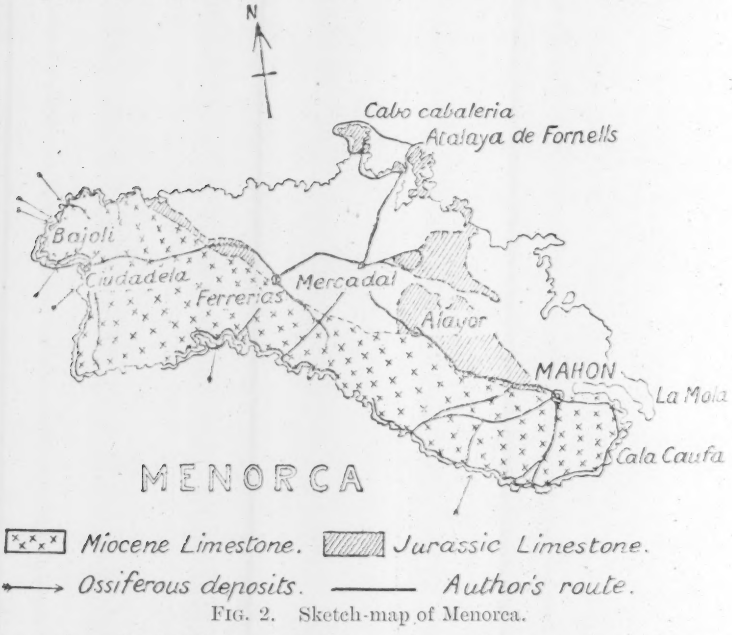


FIG. 2. Sketch-map of Menorca.

averaging about 200 feet in height. Especially at no great distance from its coastal edge this country is cut by innumerable barrancos, which are almost all narrow and range from a few hundred yards to several miles in length; many have precipitous sides, which may attain as much as 200 feet in height.

Seven ossiferous deposits were discovered, all within the Miocene Limestone area and all close to the sea. The following is a list of the localities:—

1. Fissure, Torre Vieja, Bajoli.
2. Small fissure, Sestrucarias, Bajoli.
3. Fissure, Sestrucarias, Bajoli.
4. Ossiferous deposit near Ciudadela Lighthouse.
5. Ossiferous deposit in cliffs south of Ciudadela.
6. Cave near Santa Galdana Barranco.
7. Ossiferous deposit near Cala de Binidali.

Besides the above, some fragmentary remains consisting of a few land shells and a small piece of bone embedded in the typical red matrix were found in a coast cave east of the mouth of the Santa Galdana Barranco. These no doubt indicated the former existence of an ossiferous deposit.

Two of the deposits, Nos. 4 and 5 in the list, were situated in low cliffs and were but a few feet above the sea. So little remained of either that their former condition could only be surmised as that of cave-deposits. The few bones left appeared to be those of *Myotragus*.

In only one instance (No. 6) were ossiferous remains found actually in a cavern. This was in the Cueva de los Extranjeros, so called from the neighbourhood of some deserted barracks, a relic of the British occupation; this cavern is situated in the cliffs between the mouth of the Santa Galdana Barranco and the small bay of Marcaria. It faces the sea, from which it is only separated by a few yards of sloping rock. Most of the single chamber was roofed and ran in for a distance of about 84 feet, the width being 15 to 20 feet and the height 25 to 30 feet.

At the entrance the floor was heaped with irregular blocks of stone, doubtless the result of incursions by the sea. The inner 18 feet were covered by a sloping sandy deposit, which, at one point, rose to within 8 feet of the roof. Its face had fallen away, leaving a section exposed, and this showed that the uppermost layer, 1 to 2 feet thick, contained a quantity of mammalian (*Myotragus*) remains accompanied by land shells. The entire deposit, including the ossiferous band, had evidently been introduced into this chamber by means of water which had found a way through a channel in the rock. The opening of this was found at the apex of the cave; it was choked with stalagmite, and a number of bones were also present here. The originally much greater extent of the cave breccia was indicated by the presence of land shells enclosed in red matrix at a considerable distance from the present deposit. Similar indications were observed in a second and larger cavern lying a little to the east of the one just described.

Three ossiferous deposits which had undoubtedly been accumulated in fissures in the limestone rock were found near the coast of the Bajoli district, north of Ciudadela. The cliffs in places rise to a considerable height, 200 feet and more, and this promontory, like a great part of the Miocene coastline, is edged by a barren strip of the much-weathered limestone. Here and there this was covered by long strips or sheets of stalagmite with occasional bases of stalagmitic columns.

One of the deposits (No. 2) was in a small crevice on the cliff face and near its summit. The red matrix contained a mass of small remains, including those of a dormouse, two shrews, etc. The two other fissure deposits were situated on the neighbouring farms of Sestrucarias and Torre Vieja, and were very similar; both lay parallel to the edge of the cliffs at a distance of perhaps a hundred yards and within the barren border mentioned above. Likewise both were intersected by a narrow gully leading to the sea. In each case there remained but the merest remnant of the original deposit, which barely retained anywhere a thickness of a foot, and in many places only sufficient matrix was present to contain a thin section of bone.

The Sestrucarias deposit was perhaps the more weathered of the two. Traces of it 2 yards in width could be seen to the left of the gully for a distance of about 20 yards. Similar pieces of red matrix and bones occurred at the bottom of the ravine and again for another 60 yards beyond. The second of these deposits (Pl. XXV, Fig. 2) was found in and around a slightly larger ravine terminating in an opening to the sea known as the Cala de Pous. The ossiferous remains were observed in the bed of the barranco, in the rocks forming its steep sides, and also beyond its limits. Though difficult to estimate correctly the original size of the deposit, it could be traced for 20 feet or more from either edge of the barranco and had a width of at least 40 feet and a depth of 10 to 12 feet.

The remains were almost all those of a gigantic land tortoise[1]; a few bones and teeth of *Myotragus* were obtained at the top of the smaller deposit and some rodent and bird bones occurred in the larger one. Some fine sections were made from the limestone and the red matrix of these deposits, and were kindly examined by Mr. R. Bullen Newton, who found them to be almost entirely composed of remains of *Amphistegina* accompanied by the marine Alga, *Lithothamnium*. The former had not previously been recorded from this locality.

One more ossiferous deposit discovered in Menorca was situated within a few yards of the edge of the sea cliffs near the little Bay of Binidali on the coast between the villages of San Clementi and San Luis. It had probably been formed in a fissure, and, though smaller and very fragmentary, was not unlike those of the Bajoli promontory described above. The mammalian remains were scattered in rather isolated patches over an area about 8 or 10 yards long by 2 yards broad. The depth of the deposit nowhere exceeded 2 feet. A block of limestone lying a short distance away also showed traces of remains. *Myotragus* remains occurred here, but those of rodents and other small forms were still more plentiful.

III. Conclusion.

Some of the most interesting points with regard to the Pleistocene ossiferous deposits of the Balearics may be briefly summarised as follows:—

1. Every one of the deposits discovered both in Mallorca and Menorca was situated in close proximity to the sea.
2. All were largely, some almost entirely, destroyed.
3. Usually each deposit was composed almost entirely of the remains of a single species.
4. With the exception of some avian, small reptilian, and Molluscan remains, none were obtained of species found inhabiting the islands at the present day.
5. Remains of *Myotragus* occurred in deposits of both islands.
6. Large *Testudo* remains were found only in Menorca, while different, though closely allied, species of 'dormice' were obtained from Mallorca and Menorca respectively.

[1] *Testudo gymnesicus*, Geol. Mag., March, 1914, pp. 100–7.

Almost all ossiferous cave-deposits are formed in either one of two ways:—

1. The caves have been the haunt of predatory animals or man, who not only left their own remains in the cavern, but also those of the animals brought in as the spoils of the chase.

2. Or the remains have been introduced and accumulated through the agency of water.

I believe that all the Balearic cave-deposits have been accumulated in the latter manner, and, further, that all are now approached by their original terminal end.[1] This would help to account for all having been found on the coast, for here the action of the sea and in some cases alteration of the coast-level have aided and accelerated weathering. Thus cliff faces may be worn and broken away, leaving exposed underground channels and chambers with their accumulated contents. A continuation of this same work of destruction added to rapid weathering is sufficient to account for the very generally fragmentary state of the deposits. This last might partially explain the paucity of species. The remains may have been introduced into the caves as either skeletons or carcases, and it is the latter, no doubt, which account for the finding of associated skulls and mandibles and other bones. Similar conditions to the above have been observed by the writer in many Pleistocene cave-deposits of other islands of the Mediterranean.

II.—Notes on new or imperfectly known Chalk Polyzoa.

By R. M. Brydone, B.A., F.G.S.

(*Continued from the March Number, p. 99.*)

(PLATE XXVI.)

THE group of *Membraniporæ*, with a small median barred avicularium placed immediately above the oœcium, of which *M. Griffithi*, Bryd., is a leading instance, contains several Senonian members in addition to the Trimingham forms (*M. Trimínghamensis*, *M. anterides*, *M. humiliata*) which I have already described in this Magazine. They seem to arise first in the zone of *Micraster cor-anguinum*.

Membranipora simulacrum, sp. nov. (Pl. XXVI, Figs. 1, 2.)

Zoarium unilaminate, always adherent.

Zoœcia large, very slightly subpyriform, areas oval, with average length ·5 to ·55 mm. and breadth ·3 mm.; side walls bent slightly inwards, and so low and slender that at a hasty inspection they might be taken to be mere ghosts of some species with a low arched front wall.

Oœcia very generally present in mature zoœcia, and of circular ground plan; I have not met with a perfect specimen.

Avicularia of two kinds: (1) The characteristic accessory type: these are shuttle-shaped with rounded ends, and have an aperture of

[1] See the present writer's Notes in *Camping in Crete* (A. Trevor-Battye), p. 245, London, 1913.

similar shape but tending towards pointed ends and spanned by a crossbar dividing it into two nearly equal compartments, the upper being slightly the larger: this seems to separate the species from the *M. Griffithi* line and ally it to *M. Triminghamensis*. (2) Large vicarious inflated forms of the hourglass type with the external front wall much exaggerated and a very delicate areal rim, sometimes initiating new rows of zoœcia, but sometimes occurring in an established row: these are rare and delicate and occur very capriciously.

I have only found this species in the *cor-anguinum* zone of Kent and Hants, in which it occurs sparingly but well distributed, and once in the *Uintacrinus* band of Hants.

MEMBRANIPORA SUFFRAGISTA, sp. nov. (Pl. XXVI, Figs. 3, 4.)

Zoarium unilaminate, always adherent.

Zoœcia rather small, distinctly subpyriform, with oval areas of average length ·38 mm. and breadth ·2 to ·25 mm.; side walls wide, bearing a number of stout spine bases with depressions in their upper surfaces but not apparently perforated, and tending to overlap slightly the outer edge of the side wall; these spine bases are most prominent in the upper part of the zoœcia, but appear to occur all round the area, and the spines must have presented a very militant aspect.

Oœcia small, very globular, slightly bottle-necked, very regularly present after the earliest stages, but delicate and not often preserved, the specimen shown by Fig. 4 being exceptional.

Avicularia accessory, strongly triangular and mandibular, with the beak often produced to a great length in the later stages; a transverse bar divides the triangular aperture into very unequal compartments; no vicarious avicularia.

This species might by its spines be ancestral to *M. Triminghamensis*, but by its avicularia it is probably ancestral to *M. Griffithi*. It occurs not infrequently in the *cor-anguinum* zone of Kent and Hants and rarely in the *Uintacrinus* band and *Marsupites* zone of Hants.

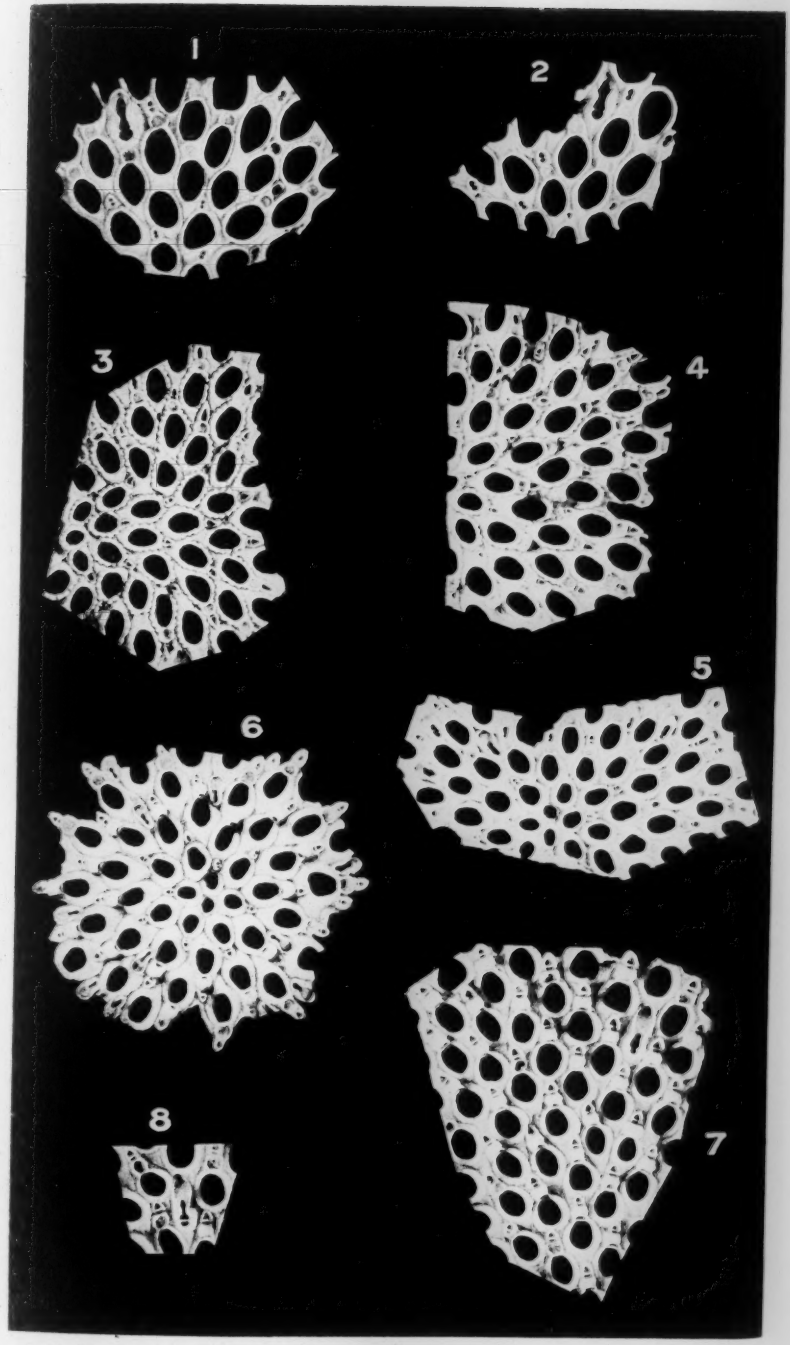
MEMBRANIPORA BOLETIFORMIS, sp. nov. (Pl. XXVI, Figs. 5, 6.)

Zoarium unilaminate, always adherent.

Zoœcia small, slightly subpyriform; areas strongly oval and usually with a flattened and straight upper end, average length ·28 to ·33 mm. and breadth ·18 to ·2 mm.; side walls typically thin, especially at the upper end; in those zoœcia, almost exclusively the very early ones, which have no oœcium there may be observed under high magnification a pair of projecting tubules on the side wall at the extreme upper end, and in most zoœcia traces of one or even two pairs of pores can be seen in the side walls a little lower down, but these features require a much higher magnification than twelve diameters for making them apparent, and I think they are only relics of discarded appendages.

Oœcia almost invariably present after the earliest stages, relatively rather large, globular, and slightly bottle-necked, rarely preserved, the specimen shown by Fig. 6 being most exceptional.

Avicularia of two kinds: (1) The characteristic accessory type, always present, bluntly triangular, with a slightly rounded lower end,



R. M. Brydone, Photo. Bemrose, Collo.

Chalk Polyzoa.

the aperture divided by the crossbar into distinctly unequal compartments, but not definitely mandibular. (2) Vicarious, occurring chiefly at the beginning of a new row of zoœcia, but sometimes also in an already established row; they are of the hourglass type with the expanded upper part of the area almost circular, but the lower part narrow and with nearly upright side walls, giving a general outline resembling that of a puff-ball; the transverse bar (which was probably always present in the hourglass type) is placed close to the lower end of the area.

This species occurs in, and seems to monopolize as far as its group is concerned, the zones of *O. pilula* and *A. quadratus* in Hants and Sussex. It is clearly ancestral to *M. Griffithi*.

MEMBRANIPORA GRIFFITHI, mihi.[1] (Pl. XXVI, Figs. 7, 8.)

I take the opportunity of giving photographic figures of this species to assist comparison and correct in small details the original figure. The side walls show a marked tendency to thin away at the upper end, and just about at the point where this thinning begins traces of a pair of pores can be detected. The zoœcia were wrongly stated to have a common external front wall; they are subpyriform with unusually prominent areal margins. The oœcia are strongly bottle-necked, and appear to be not only cut away round the avicularia but also somewhat cut down to them. I am able to figure what is probably a perfect vicarious avicularium with the transverse bar preserved. The species occurs also in the Weybourne Chalk.

EXPLANATION OF PLATE XXVI.

(All figures × 12 diams.)

FIG. 1. *Membranipora simulacrum.* Zone of *M. cor-anguinum.* Gravesend.
,, 2. ,, ,, ,, ,, ,,
,, 3. *M. suffragista.* ,, ,, ,,
,, 4. ,, ,, ,, ,,
,, 5. *M. boletiformis.* ,, *A. quadratus* (restricted). Shawford, Hants.
,, 6. ,, ,, *A. quadratus* (restricted). Seaford, Sussex. A thick-walled variety.
,, 7. *M. Griffithi.* Trimingham.
,, 8. ,, ,,

III.—On a Femur of Reptilian Type from the Lower Carboniferous of Scotland.

By D. M. S. WATSON, M.Sc., Lecturer in Vertebrate Palæontology in University College, London.

(PLATE XXVII.)

WHILST looking over the private collection of fossil fishes made by the late Dr. R. H. Traquair, I found a small tetrapod femur. This bore no label of any kind, but was included in a series of remains of Dipnoi from the Lower Carboniferous of Scotland. The texture

[1] GEOL. MAG., 1906, pp. 289-300, Fig. 1.

of the bone is not unlike that of *Ctenodus*, and was no doubt the reason of its place in the collection.

The very small piece of matrix which is preserved is identical with that of some of the fish from the No. 2 Ironstone, Loanhead, and differs from any other fish-bearing matrix that I know in Britain. [Any one with experience of Carboniferous fishes will recognize that it is usually fairly easy to identify the important localities (the Loanhead ironstones, the various Staffordshire ironstones, etc.) by inspection of the matrix.] Despite the fact that it was not localized, I think that the probability of its being from the Loanhead ironstones is sufficient to justify a description.

Mr. Herring's excellent photographs reproduced in Plate XXVII will give a much better idea of the bone than any description. The head shows a large half-moon shaped area for an articular cartilage, and is directly continuous with the small trochanter, which is carried on by a sharply marked ridge down the rather stouter shaft.

There are two rather unusually distinct condyles at the lower end which were also covered by a cartilaginous cap during life. That this little femur is of reptilian type is obvious; it resembles closely that of *Trispondylus* and even those of certain Pelycosaurs. Such Cotylosaurs as *Labidosaurus* only differ in their more pronounced trochanter. The only amphibian femora which at all resemble it are those of *Trematops* and the Lower Carboniferous *Pholidogaster*. Both, however, differ in their much less distinctly divided lower end, but do resemble it sufficiently to suggest that it is not inconceivable that it is really a precociously advanced Stegocephalian.

I showed some time ago that the Carboniferous Embolomerous Stegocephalia (which are known from the Burdiehouse Limestone) resemble the Cotylosaurs, particularly *Seymouria*, much more closely than do any later amphibia, and suggested that the reptiles arose from the Stegocephalian stock at its base. If the bone figured in this paper be really a reptile, and if it really comes from the Loanhead ironstone, it affords strong additional support to this view, for it is nearly as old as the oldest known Stegocephalian bones and much more ancient than any previously known reptile. In any case it is most probable from general experience that the reptiles did arise from the base of the amphibian stem, or all its later members by adopting some specialization have lessened their potentiality, just as the cells of an embryo when once divided into epiblastic and endoblastic layers are no longer individually capable of giving rise to the whole animal.

There is no doubt that this femur represents a new type, and I am glad to have an opportunity of expressing the pleasure that Dr. Traquair's papers have always given me by calling it *Papposaurus Traquairi*, gen. et sp. nov.

EXPLANATION OF PLATE XXVII.

Type femur of *Papposaurus Traquairi*, gen. et sp. nov. × 1. A, dorsal aspect; B, ventral aspects; C, fibial side; D, tibial side; E, proximal end; F, distal end. ? Lower Carboniferous of Scotland.

Femur of *Papposaurus Traquairi*, sp. nov.
Lower Carboniferous, Scotland.

SEDGWICK MUSEUM NOTES.

IV.—NOTES ON THE GENUS *TRINUCLEUS*.—PART III.[1]

By F. R. COWPER REED, Sc.D., F.G.S.

(PLATES XXVIII AND XXIX.)

I. THE GLABELLA.

1. *The Lobation.*

THE characters of the lateral furrows of the glabella and of the pits which occur in the axial furrows of the head-shield have not had sufficient attention paid to them, and a comparative study of their development in various British species reveals some interesting and important features.

It has been commonly assumed that lateral furrows are absent in some species, and at any rate the omission of any notice of their occurrence in certain cases is difficult to understand. Frequently, moreover, it has been stated that only two pairs are present, even in those species in which the presence of any lateral furrows has been recognized. The nature of the so-called stalk or neck of the glabella has been also generally misunderstood. McCoy's[2] division of the genus *Trinucleus* into two genera, *Trinucleus*, sens. restr., and *Tretaspis*, was largely based on the presence or absence of this stalk and of lateral furrows; for he says the furrows at the base of the glabella distinguish *Tretaspis* from *Trinucleus*, the latter being stated to be without lateral furrows, though the presence of the 'eye-line' on the cheek was chosen as the primary distinctive feature of the former. Nicholson and Etheridge,[3] while rejecting *Tretaspis* as a sub-generic division, mention an additional third pair of furrows at the sides of the anterior swollen portion of the glabella in *Trinucleus Bucklandi*, though they do not seem to regard them as segmental furrows.

In the recent new edition (1913) of the Eastman-Zittel *Text-book of Palæontology* the old genus *Trinucleus* is split into three genera, of which two (*Trinucleus*, sens. restr., and *Tretaspis*, McCoy) are said to possess two pairs of lateral furrows on the glabella. Additional confusion is thus introduced into the usage of the terms. In the case of the third genus, *Cryptolithus*, Green, of which *Cr. Goldfussi* (Barr.) is figured as an example, no mention is made of any furrows or pits and none are shown in the figure. Ruedemann,[4] however, recognized three pairs of lateral pits in *Tretaspis reticulatus*, Rued.

The general failure to recognize more than two pairs of segmental furrows or pits on the glabella is undoubtedly due to the comparatively weak development or obsolescence of the first or anterior

[1] Parts I and II were published in 1912 (GEOL. MAG., Dec. V, Vol. IX, pp. 346–53, 385–94).

[2] McCoy, Syn. Palæoz. Foss. Woodw. Mus., 1855, pp. 144–7.

[3] Nicholson & Etheridge, Mon. Silur. Foss. Girvan, fasc. ii, pp. 190–7, 1880.

[4] Ruedemann, Bull. 49 New York State Mus., Palæont. Papers 2, 1901, p. 41, pl. iii, figs. 11, 15–20.

pair, and it is only the second and third pairs to which reference is usually made. In all the best-known British species there are three pairs present, though they are in various stages of development or obsolescence, the first pair indenting the sides of the so-called 'frontal lobe', which is therefore not homologous with the true frontal lobe of other genera (e.g. *Cheirurus*) in which the first lateral furrows bound the frontal lobe posteriorly. For this reason the ovoid or sub-hemispherical swollen anterior portion of the glabella in those species of *Trinucleus* with a stalk or neck to the glabella may be termed the pseudo-frontal lobe.

Another character which has been usually neglected in describing the head-shield is the true course and behaviour of the axial furrows. For it is not usually made clear in descriptions of the glabella that the longitudinal depressions or furrows bounding the stalk of the glabella on each side are not the posterior continuations of the axial furrows but different structures of the nature of the longitudinal furrows bounding the median lobe in some species of *Lichas* and *Acidaspis*, and that there is a more or less definite elongate composite lateral lobe between the stalk and the true axial furrows, as in some species of *Ampyx*. The presence of these composite lateral lobes has generally been overlooked, and the stalk has been regarded as representing the whole posterior width of the glabella, in spite of the meso-occipital ring extending further out on each side at its base.

Certain other pits associated with the axial and other cranidial furrows have been insufficiently noticed in the past, and the fact that the segmental furrows are mostly reduced to pits situated at the inner ends of obsolescent or obsolete furrows has led to confusion in the homology of the five or six pits which are frequently present on each side of the glabella.

The reduction of the segmental furrows to mere isolated pits on the surface of the glabella is by no means uncommon in various genera of different orders and families of trilobites (e.g. *Bronteus*, *Bronteopsis*, *Oryctocephalus*, and some species of *Acidaspis*, *Dalmanites*, and *Cybele*), leading to the more or less complete longitudinal fusion of the lateral lobes of the glabella and the formation of composite lateral lobes as sometimes in *Lichas*.

In the genus *Trinucleus* the British species which shows the nature and number of the segmental furrows and the course of the axial furrows better than any other is *Tr. fimbriatus*, Murchison, from the Llandeilo of Builth (Pl. XXVIII, Figs. 1–3). McCoy[1] described and figured this species from Pencerrig, Builth, and showed in his figure the posterior course of the true axial furrows (though not quite correctly), and the presence of the elongated composite lateral lobes on each side of the neck, but he does not comment on this peculiarity, and only mentions the occurrence of two lateral furrows on each side. A study of a large series of specimens from this locality allows of a fuller description of the head-shield of this interesting species. The anterior half of the glabella is swollen and sub-pyriform, forming the pseudo-frontal lobe; the posterior half is depressed rather suddenly behind it. There is a pair of small, short

[1] McCoy, Syn. Palæoz. Foss. Woodw. Mus., 1855, p. 146, pl. i E, fig. 16.

furrows (the first lateral pair) indenting the base of the sides of the pseudo-frontal lobe close to the axial furrows; a weak, narrow depression runs obliquely inwards and backwards from these indentations to the second pair of lateral furrows, which are represented by large isolated pits at the base of the pseudo-frontal lobe; the third pair of pits lie in the same longitudinal axial line as the second pair; a short arched furrow runs back from each of these third pits, ending on each side in a deep but smaller pit in the meso-occipital furrow, so that a fourth pair of pits is here present. The short curved furrows between these third and fourth pairs embrace between them a slightly swollen basal ring, forming the posterior end of the incipient stalk of the glabella. Outside and between the third and fourth pairs of pits, there is usually a small pit of somewhat uncertain significance, but perhaps representing the outer ends of the third lateral furrows, as it seems to lie in the axial furrows. The true meso-occipital ring extends laterally outside the above-mentioned basal ring, thus proving that the true base of the glabella is wider than this ring, and, therefore, than the stalk of the glabella; and we are thus prepared to find portions of the glabella on each side of the stalk, and to look further out for the posterior course of the axial furrows.

The axial furrows are seen to hold at their anterior ends the small pits which have been erroneously[1] considered to be for the insertion of the antennæ,[2] and may therefore be called pseudo-antennary pits. From these pits they curve gently outwards with a slight convergence posteriorly to the first lateral furrows, but behind them they become gradually weaker, though distinctly traceable for fully three-fourths of the way back to the base of the head-shield, separating the suddenly rising cheeks on the outer side from elongated slightly convex areas on the inside extending from the first lateral pits to the meso-occipital ring, but depressed below the level of the median portion of the glabella—the incipient stalk. These areas are the composite lateral lobes, now merely indented on their inner sides by the pit-like second and third lateral furrows, but bounded externally by the axial furrows. The posterior ends of the axial furrows are almost obsolete, but their position is marked on each side by a notch in the posterior margin of the head-shield and by the junction of the meso-occipital and pleuro-occipital rings.

We thus see distinctly that the glabella in this species consists of (1) a pseudo-frontal lobe, (2) a median posterior stalk-like portion, and (3) a pair of elongated composite lateral lobes.

We also note that there are three pairs of segmental furrows, of which the second and third pairs are represented by more or less isolated pits not connected with the axial furrows; and that the third pair is connected with a fourth pair of pits lying in the meso-occipital (but not in the axial) furrows, leading to the formation of a basal transverse swelling or ring.

Finally we note the incipient obsolescence of the true axial furrows behind the first lateral furrows. All these features we find reproduced

[1] Oehlert, Bull. Soc. Géol. France, ser. III. vol. xxiii, p. 302, 1895.
[2] McCoy, Syn. Silur. Foss. Irel., 1846, p. 42.

with modifications in other species, such as *Tr. seticornis*, *Tr. Bucklandi*, *Tr. Murchisoni*, etc.

In the case of *Tr. Murchisoni*, Salter,[1] from the British Arenig rocks (Pl. XXVIII, Figs. 4, 4*a*), the incipient differentiation of the stalk of the glabella is rather less advanced. The glabella as a whole is of an ovoid form with the anterior part more inflated than the posterior, but the pseudo-frontal lobe sinks down more gradually into the stalk, which is not so independently cylindrical as in *Tr. fimbriatus*. The first lateral furrows are very short deep notches arising from the axial furrows and indent the sides of the pseudo-frontal lobe at about half its length, but they are not connected with the second pair by any groove or depression as in *Tr. fimbriatus*. The second pair are large deep subcircular pits completely isolated from the axial furrows, and lying at the base of the pseudo-frontal lobe and inside the line of the first pair of furrows. The third pair of large broad crescentic furrows begin anteriorly in pits and curve back to the meso-occipital furrow so as to embrace, as in *Tr. fimbriatus*, a basal ring less strongly marked than in that species, ending in a faintly impressed fourth pair of pits in the meso-occipital furrow. The lateral composite lobes are readily distinguishable, particularly in impressions of the surface of the head-shield, and extend back as depressed sub-lanceolate areas from the first lateral furrows to the base of the glabella, but they are less swollen and distinct than in *Tr. fimbriatus*.

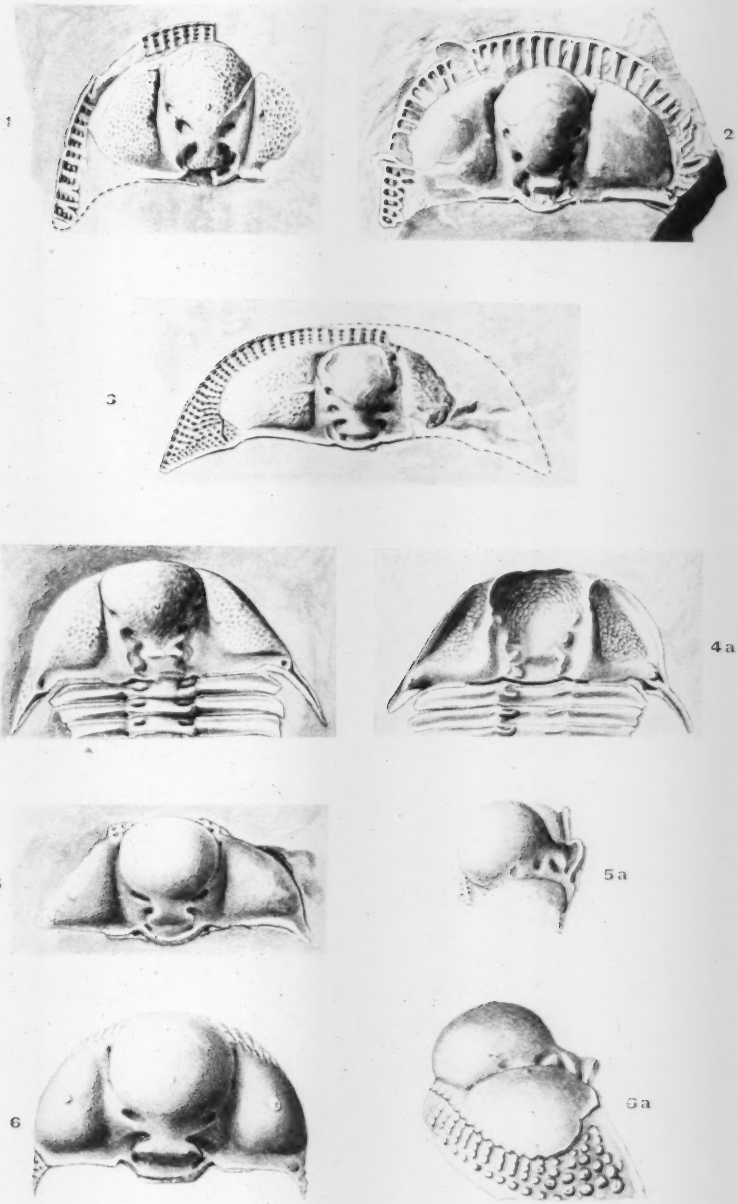
The axial furrows start anteriorly in well-marked pseudo-antennary pits, become less deep and wider behind the first lateral furrows, and curve in gently posteriorly. No sub-marginal pits or notches seem to be present at their posterior ends as in some species, but their position is marked by the size of the meso-occipital ring and its lateral extension outside the longitudinal line of the lateral glabellar pits.

In *Tr. Etheridgei*, Hicks,[2] the characters of the glabella and furrows appear to be closely similar.

Tr. Gibbsi, Salter,[3] is probably allied, but none of the specimens which I have examined allow the lobation of the glabella to be as completely determined as in the species above described, and Salter's figure is diagrammatic.

We pass now to *Tr. seticornis*, auctt., using the specific name in the broad sense common in this country. Specimens from the Sholeshook (Pl. XXVIII, Figs. 5, 5*a*), Slade, and Redhill Beds of Pembrokeshire and from the Ashgillian of the North of England show a well-differentiated swollen pseudo-frontal lobe, with the first furrows represented by shallow small pits at its sides close to the axial furrows and at about half its length. The second pair of segmental furrows consist of large deep completely isolated pits at the base of the pseudo-frontal lobe. The third pair are, as usual, in the same axial line as the second pair and are crescentic in form, beginning anteriorly in pits and ending behind in a fourth pair of pits in the

[1] Salter, Mem. Geol. Surv., vol. iii, p. 515, pl. xi B, fig. 4.
[2] Hicks, Quart. Journ. Geol. Soc., vol. xxxi, p. 182, pl. ix, fig. 6, 1875.
[3] Salter, Mem. Geol. Surv., vol. iii, p. 516, pl. xii, fig. 10.



F. A. Bather del.

Glabella of *Trinucleus*.

meso-occipital furrow, thus bounding laterally a more or less marked basal ring. The stalk of the glabella is of a sub-cylindrical shape; it is well marked off from the pseudo-frontal lobe in front and from the depressed almost obsolete narrow composite lateral lobes, which have suffered such reduction as almost to escape notice, though they are still more clearly traceable in some specimens than in others. The posterior ends of the axial furrows, which have almost disappeared behind the pseudo-frontal lobe, being lost in the wide depression between the stalk of the glabella and the cheeks, are marked by a strong pair of sub-marginal pits, lying very close to the posterior edge of the head-shield, outside the axial line of the glabellar pits and at the sides of but behind the meso-occipital ring. Between successive thoracic segments there are similar pits in the axial furrows. It may here be remarked that the fact that the anterior width of the first and following rings of the thoracic axis is considerably greater than that of the stalk of the glabella indicates that this stalk does not really correspond to the total width of the axial (i.e. glabellar) portion of the head-shield. The sub-marginal intersegmental axial pits of the thorax as well as the sub-marginal pits of the head-shield thus lie in a longitudinal line outside the second and third pits of the glabella.

The pseudo-antennary pits in *Tr. seticornis* are always distinct and in their typical position.

The allied *Tr. Bucklandi*, Barr.,[1] as represented by the smaller specimens from Girvan[2] (Pl. XXVIII, Figs. 6, 6*a*; Pl. XXIX, Fig. 1) which appear to completely agree with Bohemian examples and to differ slightly from the larger specimens from Girvan attributed to the same species, has the pseudo-frontal lobe differentiated as in *Tr. seticornis*, and the first pair of lateral furrows of the glabella of the same character and in the same position. The second pair of furrows are not, however, simply pits, but form short, deep, transversely oblique furrows, bounding the pseudo-frontal lobe behind, but they do not arise quite from the axial furrows, though very near them, and they extend about one-third of the way across the width of the glabella on each side, deepening internally and ending abruptly. The third pair of furrows are also not simply isolated pits on the surface of the glabella, but are short, transverse, broad furrows arising nearly from the axial furrows with their inner ends deepest; they are also directed obliquely forward to the middle, and are only feebly connected behind with the deep fourth pair of pits in the meso-occipital furrow. The single lateral composite lobe is thus almost segmented and tends to be split up into imperfectly separated paired lateral lobes owing to the length of the second and third pairs of furrows, but the lobes are not clearly individualized. The lateral furrows are better developed and less reduced in this species than in the others. Owing to the weakness of the connexion between the third pair of furrows and the fourth pits, the basal ring is obscurely defined, but the stalk of the

[1] Barrande, Syst. Silur. Bohême, vol. i, p. 621, pl. xxix, figs. 10–17.

[2] Nicholson & Etheridge, Mon. Silur. Foss. Girvan, fasc. ii, p. 190, pl. xiii, figs. 14, 15, 20; Reed, Girvan Trilobites, 1903, pt. i, p. 10, pl. i, fig. 11.

glabella is swollen at its base and has a decided sub-nodular elevation at each side between the oblique third furrows and the meso-occipital stalk. The fourth pair of pits are large and deep. The sub-marginal pits at the posterior ends of the feebly impressed axial furrows are smaller than the others and lie outside the longitudinal lines in which they are arranged, as in *Tr. seticornis*. Though the axial furrows are indistinctly marked behind the pseudo-frontal lobe, and a wide depressed area on each side of the stalk of the glabella separates the latter from the cheeks, yet they can be traced with care the whole way back from the pseudo-antennary pits to the sub-marginal pits, and indicate the true ovoid shape of the entire glabella.

In the larger specimens of *Tr. Bucklandi* from Girvan (Pl. XXIX, Fig. 2), usually considered as the adult form of those above described, the first pair of lateral furrows is better marked, and the second and third pairs nearly meet at their inner ends; the lateral composite lobe is more differentiated and swollen along the axial furrows, and there is a small outer extra pit lying in or nearly in the axial furrows between the third and fourth pairs, as in *Tr. fimbriatus*. The formation of the basal ring, and the size and development of the fourth pits, the pseudo-antennary pits, and sub-marginal pits are as in the smaller form. Nicholson & Etheridge[1] noticed the first pair of lateral furrows in this species, and they were faintly shown in some of my figures of the species,[2] but their character and homology were not discussed. The general ovoid outline of the glabella is well seen in these specimens, the axial furrows being distinctly visible on each side, curving gently in with a slight convergence to the base of the glabella. In this form we may specially notice the strength of the lateral furrows, their approximate entry into the axial furrows, and the consequent tendency for the elongate composite lateral lobe to be resolved into its several pairs of lobes, the second pair of lateral lobes (between the second and third pairs of furrows) being nearly quite marked off and circumscribed. McCoy[3] in describing this species seems to have observed second, third, and fourth pairs of pits or furrows, for he says "the posterior half of the glabella [is] abruptly contracted to a narrow neck with a distinct neck-furrow [= meso-occipital furrow] and two short segmental furrows at each side [= second and third lateral furrows], the ends forming *three* deep punctures in casts". It may be mentioned here that the median tubercle on the pseudo-frontal lobe, which is so conspicuous in the smaller form, is much reduced and sometimes wanting in these larger specimens of *Tr. Bucklandi*.

Without attempting to discuss the form from Scania referred by Olin[4] to *Tr. Bucklandi*, it may be remarked that his figures indicate clearly that the glabella has an ovoid shape and includes lateral composite lobes scarcely differentiated from a median stalk, with well-developed true axial furrows.

[1] Nicholson & Etheridge, op. cit., p. 192.
[2] Reed, op. cit., pl. i, figs. 10, 13.
[3] McCoy, Syn. Pal. Foss. Woodw. Mus., p. 147.
[4] Olin, "Chasmopsk. o. Trinucleusskiffern i Skane": Medd. fr. Lunds Geol. Fältklubb, ser. B, Nr. i, 1906, p. 66, t. iv, figs. 1*a*, *b*.

The species *Tr. hibernicus*, Reed,[1] has the development of the stalk of the glabella even more advanced than in *Tr. Bucklandi* or *Tr. seticornis*, the sub-spherical pseudo-frontal lobe being sharply marked off from it, and the stalk itself being quite independently semi-cylindrical. Traces of the first pair of lateral furrows are visible as weak indentations close to the axial furrows; the second and third furrows are represented by deep transverse isolated pits, but the third pair has the curved extension backwards to enclose the distinct basal ring. Sub-marginal pits mark the posterior ends of the axial furrows, which are faintly traceable all the way back to them, but the composite lateral lobes are indistinct, though there is the narrow, elongated, depressed space on each side of the stalk occupying their place.

Tr. albidus, Reed,[2] from the Whitehouse Group (M. Bala) of Girvan, has an unusually large ovoid pseudo-frontal lobe and a well-defined semi-cylindrical stalk. The lateral furrows seem to be obsolete, and the composite lateral lobes and posterior part of the axial furrows have disappeared; but the fact that the meso-occipital ring extends on each side of the base of the stalk shows that the structure of the glabella is on the same plan. We must regard it as an extreme case of suppression of segmental and primitive characters.

We come now to a different group of species, including the somewhat varied assemblage of forms called *Tr. concentricus*, or named varieties of it. In these the stalk is not developed in the glabella and the lateral furrows are nearly obsolete.

The specimens of *Trinucleus* from the Bala Beds of the Onny River (Pl. XXIX, Figs. 3, 3*a*) usually referred to this species have an elongated ovoid glabella without any differentiation into a more swollen anterior, pseudo-frontal lobe and a depressed stalk; there is no sudden contraction in width, but the glabella decreases gradually in height and width to its base, the axial furrows being gradually convergent behind, but of uniform depth and strength. The glabella at first sight appears devoid of any traces of segmentation, but from the examination of a large number of specimens in different states of preservation it can be confidently asserted that three pairs of isolated lateral pits are present, though they are generally very faint or nearly obsolete. All of them lie inside the axial furrows and on the sides of the glabella. The first pair is usually obsolete; the second pair is very shallow, transversely oval, and half-way between the first and third pairs; the third pair is sometimes more of a furrow than a pit, and may obscurely mark off an incipient basal ring. A fourth pair of pits lying in the meso-occipital furrow (as in the *seticornis* group of species) is generally distinct, and lies in the same axial line as the other pairs of pits, but is not connected with the third furrows. Pseudo-antennary pits are always present at the anterior ends of the axial furrows, and sub-marginal pits at their posterior ends lying at the sides of the meso-occipital ring and outside the lines of the glabellar pits. A median tubercle on the glabella behind the level of the first pair of pits is present, and the meso-occipital segment is furnished with a horizontal nuchal spine.

[1] Reed, GEOL. MAG., Dec. IV, Vol. II, p. 52, Pl. III, Figs. 2–7, 1895.
[2] Reed, Mon. Girvan Trilob., Suppl., 1914, p. 3, pl. i, figs. 1, 2.

In *Tr. favus*, Salter,[1] the glabella (Pl. XXIX, Fig. 4) has the same shape and characters as these Onny specimens of *Tr. concentricus*; three pairs of small shallow isolated pits can be more easily detected on the lateral slopes of the glabella, all unconnected with the axial furrows, the first ones being as much isolated as the others, but all are equidistant and sub-equally developed. A small fourth pair of pits in the meso-occipital furrow is also visible and pseudo-antennary pits at the anterior ends of the axial furrows. There is a median tubercle also on the glabella. Practically the segmentation and pitting is the same as in *Tr. concentricus* of the Onny River. *Tr. favus* is typically a Llandeilo form.

There is a form of *Trinucleus*, usually referred now to *Tr. concentricus*, which was separated by McCoy[2] as a distinct species which he called *Tr. gibbifrons* (Pl. XXIX, Figs. 5–7). The type-specimen of it cannot be found, but there are several specimens in the Sedgwick Museum from the Bala Beds of Allt yr Anker, Dinas Mawddy, and Pen y Craig, which were labelled by McCoy as *Tr. gibbifrons* and possess the characters which he described. In this form the glabella is shorter, broader, and more inflated than in the Onny River *Tr. concentricus*; the anterior part of the glabella is somewhat independently swollen into an incipient pseudo-frontal lobe; the posterior and shorter part of the glabella is slightly contracted at the base of this lobe and rather suddenly depressed, suggesting the formation of a stalk. The first pair of lateral pits is very weak and often scarcely discernible, indenting the sides of the anterior swollen portion; the second pair is likewise very faint or obsolete. There are then two much more distinct small sharply marked deep pits on each side of the base of the glabella; the anterior of these pits lies almost in the axial furrows and probably corresponds with the third pair in *Tr. concentricus* and others, but must represent the outer instead of the inner ends of these furrows (see remarks on *Tr. Goldfussi* below); between this pair a slight annular basal swelling of the glabella is noticeable, suggesting the basal ring of *Tr. Bucklandi*, etc. The posterior pair of pits apparently correspond with the fourth pair in the meso-occipital furrow, and are rather more inwardly situated than the third pair. The pseudo-antennary pits at the front ends of the axial furrows and the sub-marginal pits at their posterior ends are well marked. The axial furrows themselves are wider and less deeply impressed towards the base of the glabella, but there are no composite lateral lobes and the axial furrows plainly bound the glabella for its whole length and width. There is no horizontal nuchal spine to the meso-occipital ring, but a strong pointed median tubercle or short vertical spine is present on this ring. A median tubercle also is present on the swollen anterior part of the glabella.

We may regard this form, *Tr. gibbifrons*, as belonging to a parallel line of development to *Tr. seticornis* and its allies, but not directly connected with it. The inception of a pseudo-frontal lobe and stalk

[1] Salter, Mem. Geol. Surv., vol. ii, pt. i, p. 350, pl. ix, fig. 3; vol. iii, p. 517, pl. xiii, fig. 9; dec. vii, pl. vii, p. 6.

[2] McCoy, Syn. Pal. Foss. Woodw. Mus., p. 145, pl. 1E, figs. 14, 14*a*.

and of a basal annular swelling are points of resemblance in the glabella, but the furrows and lobation are quite different.

The Bohemian species *Tr. Goldfussi*, Barr.,[1] of which I have examined nearly a dozen examples of the head-shield, appears to furnish an explanation of the two pairs of small but deep and well-marked pits at the base of the glabella, which I have described above in *Tr. gibbifrons*. For in *Tr. Goldfussi* there are, in addition to these small deep pits, three pairs of very shallow isolated pits of larger size and set at equal distances apart on the flanks of the glabella, as in the Onny River specimens of *Tr. concentricus*. These pits are only rarely visible, but where present the third pair is continued back by very weak furrows to the small deep pits in the axial furrows, thus showing that these pits may be regarded as marking the outer ends of the third lateral furrows. Behind them come the similar small deep pits in the meso-occipital furrow, as in *Tr. gibbifrons*. These two pairs of small pits are shown in Barrande's figures of *Tr. Goldfussi* and seem to be generally developed in all its allies.

In *Tr. Nicholsoni*, Reed,[2] the glabella has the elongated ovoid shape of *Tr. concentricus* (Onny River form), narrowing gradually behind, but the anterior part is more swollen and there is a median tubercle as in *Tr. gibbifrons*. The axial furrows are very deep and converge regularly behind without any contraction; the first and second furrows are very shallow faint depressions in the axial furrows, indenting the base of the sides; the third and fourth pairs of pits are sharp and deep, like those in *Tr. gibbifrons*, and there is likewise a weak basal annular swelling with low lateral nodules. A nuchal spine is present as in *Tr. concentricus*. Undoubtedly this species is closely connected with the latter.

With regard to the distinct species or varieties of *Tr. concentricus* described by Portlock from Tyrone, we can only speak with certainty of the form known as *Tr. concentricus*, var. *elongatus*,[3] so far as the characters and lobation of the glabella are concerned. This form has a long sub-pyriform glabella much like that of the Onny River *Tr. concentricus* in general shape; the pseudo-antennary pits are distinct; there are no traces of any first or second pairs of furrows or pits; two pairs of small deep, rather closely placed pits at the base of the glabella represent the third and fourth pits, the anterior pair of which lie in the axial furrows, the posterior pair rather further inwards and in the meso-occipital furrow. Both pairs are deep and subcircular. Sub-marginal pits are also present, and the meso-occipital ring bears a sharp median tubercle.

The Girvan species *Tr. subradiatus*, Reed,[4] from the Balclatchie Beds, possesses a glabella which in its general shape (apart from its carination) resembles that of *Tr. concentricus* of the Onny River, and the meso-occipital ring has likewise a horizontal nuchal spine. The

[1] Barrande, Syst. Silur. Bohême, i, p. 628, pl. xxx, figs. 29–40; pl. xxxv, figs. 30, 31.

[2] Reed, GEOL. MAG., Dec. V, Vol. VII, p. 212, Pl. XVI, Figs. 1–9, 1910.

[3] Portlock, Geol. Rep. Londond., p. 263, pl. i B, fig. 7; B. Smith, Proc. Roy. Irish Acad., xxvi, B, 9, p. 127, pl. viii, figs. 3, 4, 1907.

[4] Reed, Girvan Trilobites, 1903, pt. i, p. 12, pl. ii, figs. 1–6.

first two pairs of lateral furrows of the glabella, though very sh and often mere notches indenting the sides of the glabella, start fr the axial furrows; the third pair is longer and oblique, the ou end of each furrow being marked by a deep pit set far back in t axial furrow. There is a fourth pair of pits transversely oval shape and set rather further inwards in the meso-occipital furro and sub-marginal and pseudo-antennary pits are likewise prese Traces of a faint basal ring are generally visible.

Several British species are not sufficiently known to enable us discuss adequately their glabellar segmentation. Such are *Tr. lat* Portl., *Tr. radiatus*, Murch., *Tr. Thersites*, Salter, and *Tr. Lloy* Murch.

In the case of *Tr. radiatus*, Murch.,[1] the second and third late furrows seem represented by two deep triangular pits, of which t anterior pair is situated behind the middle of the glabella, and t third pair has a slight connecting groove across the base of the glabel marking off a basal ring.

Salter's[2] figures of *Tr. Lloydi* show a feebly marked, narro elongated, lateral composite lobe on each side of the posterior half the glabella, and in Fig. 1* a decided basal ring, but he on mentions "a slight longitudinal depression on each side" (marki off the lateral lobe) and "one obscure lateral sulcus above the nec furrow" at its base (=the third lateral furrow). The condition the lateral composite lobes recalls that found in *Ampyx nudus*, Murc

Tr. Thersites, Salter,[3] shows no stalk and no furrows on its narr compressed carinate glabella; this species has never been figured, a the type-specimens are hardly sufficient for an adequate speci diagnosis.

EXPLANATION OF PLATES.

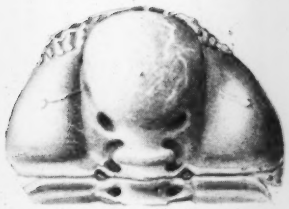
Plate XXVIII.

Fig. 1. *Trinucleus fimbriatus*, Murchison. × 3. Llandeilo Beds: P Cerrig, Builth.
,, 2. Ditto. × 2. Same horizon and locality.
,, 3. Ditto. × 3. Same horizon and locality. McCoy's figured specime Syn. Brit. Pal. Foss. Woodw. Mus., pl. i E, fig. 16.
,, 4. *Trinucleus Murchisoni*, Salter. × 2½. Arenig Series: Tasker Quar near Shelve.
,, 4*a*. Ditto. × 2½. Impression of same specimen.
,, 5. *Trinucleus seticornis*, Hisinger. × 2½. Sholeshook Limeston Sholeshook, Pemb.
,, 5*a*. Ditto. × 2½. Side view of same specimen.
,, 6. *Trinucleus Bucklandi*, Barrande (small form). × 2½. Drumma Group: Thraive Glen, Girvan. Mrs. Gray's Collection.
,, 6*a*. Ditto. × 2½. Side view of same specimen.

Plate XXIX.

Fig. 1. *Trinucleus Bucklandi*, Barrande (small form). × 2½ (with o thoracic ring attached). Drummuck Group: Thraive Glen, Girva Mrs. Gray's Collection.
,, 2. Ditto (large form). × 1½. Same horizon and locality. Mrs. Gray Collection.

[1] Murchison, Silur. Syst., pl. xxiv, fig. 3.
[2] Salter, Mem. Geol. Surv., dec. vii, pl. vii, 1853 (the figures are large restorations).
[3] Ibid., p. 7.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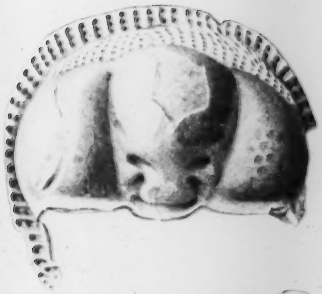
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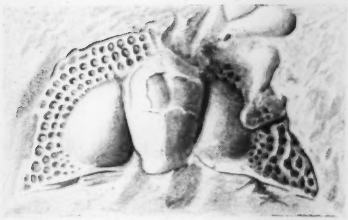
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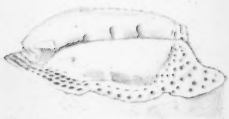
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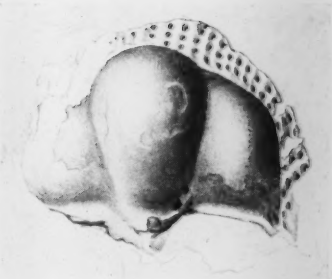
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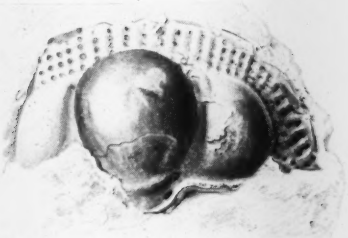
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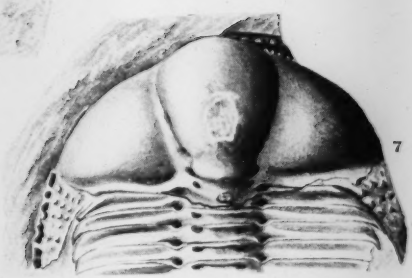
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Glabella of *Triuncleus*.

FIG. 3. *Trinucleus concentricus* (Eaton). × 2. Middle Bala: Onny River, Shropshire.
,, 3*a*. Ditto. × 2. Side view of same specimen.
,, 4. *Trinucleus favus*, Salter. × 3. Side view. Llandeilo Beds: Llandeilo.
,, 5. *Trinucleus gibbifrons*, McCoy. × 2½. Middle Bala: Wales. One of the specimens named and labelled by McCoy.
,, 5*a*. Ditto. × 2½. Side view of same specimen.
,, 6. Ditto. × 2½. Middle Bala: Gelli Grin.
,, 7. Ditto? × 2½. Starfish Bed, Thraive Glen, Girvan. Mrs. Gray's Collection.

N.B. All the specimens, except mentioned otherwise, are in the Sedgwick Museum, Cambridge.

(To be continued.)

V.—The Zone of *Offaster pilula* in the South English Chalk.

By R. M. Brydone, B.A., F.G.S.

Part I.

In the year 1911 Mr. Griffith and I [1] proposed to recognize in Hants three divisions of the Chalk intervening between the zones of *Marsupites testudinarius* and *Belemnitella mucronata*, and then known as the zone of *Actinocamax quadratus*. These divisions we were not jointly prepared to treat as more than subzonal. In the year 1912 I [2] defined the lower and middle divisions very closely and described them in detail, and demonstrated that the upper boundary of the middle division was a strongly marked break. This break I regarded as of zonal importance, and I therefore separated the lower and middle divisions from the upper as subzonal divisions of a new zone of *Offaster pilula*. I was also able to say that the features of the new zone in Hants were exactly reproduced in the Sussex cliffs and to cite as presumptive evidence that it was equally recognizable in Wiltshire a statement by Dr. Blackmore that the divisions proposed in 1911 held good round Salisbury. The object of this paper is to trace the new zone in detail in the more accessible cliff sections of the old zone of *A. quadratus* in the South of England.

The zone of *O. pilula*, as established for Hants (on inland sections only), was estimated to be about 105 feet thick, made up as follows:—

			Feet
Zone of *O. pilula*.	Subzone of abundant *O. pilula*	Upper belt of *O. pilula*, with a pair of marl seams about 18 inches apart as its base and a marl seam (succeeding about 3 feet of chalk yielding *O. pilula* of exceptional size) as its top . . . . about	13
		'Middle belt,' with few *O. pilula* and apparently no marl seams . . . . . about	20
		Lower belt of *O. pilula*, bounded above and below by marl seams . . . . . about	12
	Subzone of *E. scutatus*, var. *depressus*	Chalk with *O. pilula* occurring erratically and becoming very scarce towards the bottom; *Echinocorys scutatus*, var. *depressus*, in the upper part; *E. scutatus*, var. *tectiformis*, and abundance of *Ostrea Wegmanniana* and *O. incurva* (often in bunches) in the lower part . . . . . about	60
		About	105

[1] *The Zones of the Chalk in Hants*, London, Dulau & Co., 1911.
[2] *The Stratigraphy of the Chalk of Hants*, London, Dulau & Co., 1912.

Other noteworthy fossils of the zone are *Ostrea canaliculata*, var. *striata*,[1] and *Bourgueticrinus* Forms 1 and 2, very characteristic of the subzone of abundant *O. pilula*; *Echinocorys scutatus*, var. *cinctus*, so characteristic of the middle belt of the same subzone that I propose to call it the *Cinctus* belt; *E. scutatus*, var. *truncatus*, confined to the lower belt of the same subzone and a few feet below it; *Terebratulina Rowei*, reappearing at the base of the same subzone after disappearing at the top of the zone of *Marsupites*, and occurring chiefly in the lower belt, but occasionally also in the middle and upper belts; *Rhagasostoma palpigerum*, strongly associated with the subzone of abundant *O. pilula*; a free ramose form of *Porosphæra* with thick flattened branches, perhaps confined to the same subzone; *Bourgueticrinus* Form 5, reappearing for a short time in the upper part of the subzone of *E. scutatus*, var. *depressus*, after disappearing at the top of, if not some way down in, the zone of *Marsupites* and *Bourgueticrinus* Form 6, a very reliable guide to the subzone of *E. scutatus*, var. *depressus*, and particularly its lower beds. To these may be added a darkish, thick-shelled, and often gracefully curved form of *Ostrea incurva*, which is very closely associated with the upper belt of the subzone of abundant *O. pilula* and almost confined to it.

I. Sussex.

From Black Rock, Brighton, to Newhaven, a distance of some 7½ miles, there is a continuous cliff. This cliff is composed entirely (except for about a mile at the Brighton end, and about half a mile in Friars Bay) of chalk of the zones of *O. pilula* and *A. quadratus*, lying in gentle folds.

A. *Subzone of E. scutatus, var. depressus.*

The base of this subzone no doubt comes in at the top of the cliff at or near Black Rock, and a gentle easterly dip brings it down to the base of the cliff a little to the east of Roedean School. This easterly dip continues towards Rottingdean, but without ever bringing the succeeding subzone in reach at the base of the cliff. A little west of Rottingdean the beds become practically level and so continue across the gap and part of the way through East Hill. Close to Saltdean Bottom the beds rise in a slight anticline, which culminates at Saltdean Bottom and brings up on the foreshore, but not into the cliff, the highest beds of the zone of *Marsupites*. The anticline has a very flat top and the beds remain practically horizontal for about half a mile; they then dip steadily eastwards and the top of the subzone passes below the foot of the cliff just east of the sewer at Portobello. The subzone is brought up again by the Friars Bay anticline, coming into the cliff about a quarter of a mile east of Friars Bay with a gentle dip which does not carry the top of the subzone out of reach until the west horn of Friars Bay is reached. The dip then increases and the whole thickness of the subzone passes up into the cliff, together with some 8 feet of the zone of *Marsupites*, before a series of minor faults appear and so neatly counteract the

[1] The mystery surrounding the origin of this most useful varietal name has not been cleared up by Mr. Woods' recent monograph. It probably originated with Dr. Blackmore.

effect of the anticline as to prevent any further chalk of the zone of *Marsupites* from coming into the cliff. After about half a mile the beds begin to dip eastwards again, and the whole thickness of the subzone passes out of the cliff into the foreshore in the course of a quarter of a mile at Old Nore Point. The syncline into which the beds are here passing is a very gentle one and culminates just west of the miniature rifle butts under Castle Hill, but the gentle westerly dip which prevails from this point to Newhaven harbour is just as likely to be due to the change of direction of the cliff giving a section along the general dip off the Wealden axis as to the approach of another anticline transverse to the general coastline. It certainly does not bring the subzone up into the cliff again. There may well be an anticline bringing up the subzone in the middle of the Ouse Valley; but in any case when the chalk reappears on the coast at the Buckle Inn, near Seaford, this subzone has sunk far below beach level and is only seen again in Seaford Head.

[The various folds which have been indicated may be labelled from west to east as—Rottingdean syncline, Saltdean anticline, Telscombe syncline, Friars Bay anticline, Castle Hill syncline, Seaford syncline, and Seaford Head anticline. They are obviously capable of being referred to just such a system, if not a continuation of the same system, of folds, oblique and secondary to the Wealden axis, as I have suggested in Hants. The Seaford syncline has been shown by Dr. Elsden to run inland obliquely to the coastline, and Meeching Quarry, Newhaven, almost certainly gives a similarly oblique line of prolongation for the Friars Bay anticline.]

The subzone varies very little lithologically in these exposures. It is 60 feet thick between Brighton and Rottingdean and again in Friars Bay and 64 feet in the Saltdean anticline, and the minute lithological details correspond so closely that it can hardly be doubted that the marl beds treated in the following section as corresponding are actually continuous over the intervening areas. Even at Seaford Head there appears to be an exact correspondence bed by bed and marl seam by marl seam, though the thicknesses of the individual beds are uniformly reduced, perhaps owing to local compression in the course of folding.

This subzone reproduces very accurately in Sussex the features ascribed to it in Hants. The lower 25 feet or so are characterized by *E. scutatus*, var. *tectiformis*, *Bourgueticrinus* Form 6, and *O. Wegmanniana* and *O. incurva* in abundance. The next 25 feet or so are characterized by *E. scutatus*, var. *depressus*, and *Bourgueticrinus* Form 5, while in the upper 10 feet or so *E. scutatus* passes rapidly into the var. *truncatus*, which becomes fully established before the subzone ends. The section indicates the lowest bed in which I have yet found *O. pilula*. It occurs in all higher beds.

It is necessary to deal with the grounds on which I have fixed my base of the subzone. As I have found normal (small and smooth) *Marsupites* plates in the cliff at Friars Bay, immediately below the lowest marl seam shown in my sections, it is clear that the zone of *Marsupites* is properly carried up to that seam, and the only question is as to the 7 ft. band of chalk separating it from the one I have

taken as the top of the zone. This band is accessible for a long distance in a wave-beaten section at Friars Bay, for a short distance in a favourable condition near Brighton (where the upper boundary is hardly marly and is little more than a parting), and for some distance, in parts of which it is in fair condition, in Meeching Quarry, Newhaven. I have not yet found even a small specimen of a normal *Marsupites* plate in this band; but small and dwarf Crinoid brachials, such as are otherwise only found in association with *Uintacrinus* or *Marsupites*, range all through this band and are fairly abundant, while occasionally very small Crinoid plates are found which may be indistinguishable from plates of *Marsupites* except for their smallness or may be practically oblong with about $\frac{1}{6}$ in. of their length flat at each end and the remainder arched. (I have once or twice found similar plates in Hants in beds which probably occupied the same position, just above the highest undoubted plates of *Marsupites*.) *Terebratulina Rowei* is also present throughout this band and in an abundance which seems quite unusual to me. At the top of this band of chalk *T. Rowei* and the dwarf plates disappear absolutely, and the brachials disappear so nearly absolutely that I have only met with very few above this band, all of which were in the lowest foot of the succeeding bed. I have also from this band one pyramidate *E. scutatus*, which if not typical of the var. *elevatus* is very much nearer to it than to the var. *tectiformis*. On these grounds I have attributed this band to the zone of *Marsupites*. *Bourgueticrinus* Form 5 has not yet been found in this band nor in the upper beds in which undoubted plates of *Marsupites* occur, and this confirms an impression I have derived from the Hants sections that it disappears before the top of the zone of *Marsupites* is reached. It is curious how consistently it seems to anticipate *T. Rowei*, which is commonly treated as having the same range. Thus *Bourgueticrinus* Form 5 is well established some way below the *Uintacrinus* band; *T. Rowei* appears to come in only a very little way below the *Uintacrinus* band; *Bourgueticrinus* Form 5 disappears apparently in the course of the zone of *Marsupites*, *T. Rowei* at its end. *Bourgueticrinus* Form 5 reappears in the middle of the subzone of *E. scutatus*, var. *depressus*, and does not seem to outlive it; *T. Rowei* does not reappear until the subzone of abundant *O. pilula*, and persists almost, if not quite, all through it.

It will be observed that the lithological features by which I have divided up the subzone are exclusively marl bands. This does not mean that I do not attach any value to lines of flint as permanent features, for I hold that they are very often persistent enough to be very serviceable. A conspicuous instance may be found in the bed I have treated as the highest bed of the *Marsupites* zone; this bed between Brighton and Rottingdean contains a line of flints from 1 foot to 18 inches down and another 3 feet lower; its flints are distributed in exactly the same way in Friars Bay, 5 miles away, and again a mile further on in Meeching Quarry, Newhaven, and at Seaford Head.

A good deal of scorn has been heaped upon the idea of lines of flint being sufficiently persistent to be of use as indices to horizon, but it will be found that many of the cases cited are really irrelevant, being cases of the impersistence of tabular veins. The presumption being

that these were formed in cracks after the chalk had consolidated, it is obvious that they have no necessary connection with bedding planes, however much they may tend to follow them, nor can their impersistency be relevant to interstratified lines of flints. At the same time marl seams as a rule are more constant than lines of flints in their individual characters: that is to say, a marl seam will retain the same degree of thickness and definiteness over a long distance, while lines of flints will often vary from wide and closely set to thinly strung out in the course of a few feet. Marl seams are therefore much more useful than flint lines in tracing the effect of the dislocations which are so often met with. I also regard them as no less persistent and as a rule more persistent than flint lines over long distances. An admirable instance is to be found in the sections under discussion in the marl bed I have called the "2 inch Marl". This bed consists of from 2 to 3 inches of solid marl, and forms a conspicuous feature in the cliff and a ready guide to the general position of the upper boundary of the subzone; it comes in just above the Roedean School tunnel and occurs with perfect regularity right away to Seaford Head. I have, therefore, on all three grounds of constancy in thickness, definiteness, and persistency, come to attach the chief importance among lithological features to marl seams.

SECTIONS THROUGH THE SUBZONE OF *E. SCUTATUS*, VAR. *DEPRESSUS*, AFFORDED BY THE SUSSEX CLIFFS.

		Brighton to Rotting-dean.		Saltdean to Tels-combe.		Friars Bay.		Seaford Head.	
	Marl seam marking base of subzone of abundant *O. pilula*.	ft.	in.	ft.	in.	ft.	in.	ft.	in.
Subzone of *E. scutatus*, var. *depressus*.	Chalk	4	0	4	6	4	3	2	6
	Thick marl seam ("2 inch Marl")								
	Chalk	14	0	14	0	13	3	10	6
	Upper of a pair of marl seams, 15 inches apart.								
	Chalk	7	0	7	0	6	6	5	6
	Upper of a pair of marl seams, 15 inches apart.								
	Chalk	8	9	9	0	8	6	7	4
	Strong marl seam.								
	Chalk	10	9	10	9	8	9	7	10
	Marl seam.								
	Chalk yielding two *O. pilula*	6	0	8	6	7	10	7	2
	Marl seam.								
	Chalk	5	0	6	0	6	0	5	8
	Marl seam.								
	Chalk	4	6	4	6	4	9	3	6
		60	0	64	3	59	10	50	0
Zone of *Marsupites*.	Thin marl seam.								
	Chalk with flint seam at 1–1½ feet down, and another at 4–4½ feet down	7	0	—		6	9	7	3
	Marl seam.								
	Chalk yielding plates of *Marsupites*	+8	0	—		+8	0	+8	0

B. *Subzone of abundant O. pilula.*

The lower boundary of this subzone comes into the cliff just opposite Roedean School, and the upper boundary also undoubtedly comes in towards the top of Beacon Hill just west of Rottingdean. Rottingdean Gap cuts clean through this subzone and into the one below, but it reappears in East Hill, where its full thickness is present and there is also room for a substantial amount of *quadratus*-chalk. Saltdean Bottom cuts again clean through this subzone, but it is clearly present in Portobello cliff in its full thickness, sinking gradually eastwards as the Saltdean anticline passes into the Telscombe syncline. In the centre of the Telscombe syncline the whole subzone passes out of the cliff on to the foreshore, the upper boundary descending several feet below high-water mark; but it soon rises into the cliff again, and then monopolizes the base of the cliff most of the way to the west end of Friars Bay and does not rise wholly out of reach until the west horn of Friars Bay is turned. Over the Friars Bay anticline it is in the upper part of the cliff, but never quite reaches the top of the cliff; even Chene Gap fails apparently to cut quite down to it. At Old Nore Point it comes down to beach level and the greater part of it passes rather quickly out of the cliff on to the foreshore; but the rapid diminution in the dip as the Friars Bay anticline passes into the Castle Hill syncline keeps the upper boundary just above beach level. From this point to Newhaven the dip (westwards) is very slight, but gradually brings the upper belt and then the middle belt and finally perhaps the top of the lower belt of the subzone into the cliff.

The subzone has sunk again below the surface when the chalk reappears above beach level at Buckle Inn, but between that point and Seaford it used to be recognizable on the foreshore at low water. At Seaford Head it reappears for the last time, emerging from behind the sea-wall with its upper boundary about 12 feet below the esplanade level and passing rapidly up through the cliff and out at the top.

The subzone is so uniform in its physical characters that the following section will apply to every occurrence of it.

SUBZONE OF ABUNDANT *OFFASTER PILULA* IN THE SUSSEX CLIFFS.

Chalk of zone of *A. quadratus*.

			ft.	in.		ft.	in.
		Marl seam.					
Subzone of abundant *O. pilula*.	Upper belt of *O. pilula*.	Chalk with very large *O. pilula*	1	0	to	1	6
		Flint seam.					
		Chalk with large *O. pilula*	1	6		2	0
		Marl seam.					
		Chalk	2	6		2	9
		Marl seam.					
		Chalk	6	6		7	6
		Marl seam.					
		Chalk	1	0		1	6
		Marl seam.					
	Lower belt of *O. pilula*.	Chalk with very few marl seams (except at Seaford Head, where there are five)	20	0		22	0
		Flint seam, often tabular.					
		Chalk with varying seams of marl and flint	10	6		11	0
		Marl seam.					
		Chalk	1	3		1	6
		Marl seam.	44	3	to	49	9

Chalk of subzone of *E. scutatus*, var. *depressus*.

The subzone in Sussex corresponds palæontologically in the closest way with the same subzone in Hants. The only guide fossil for Hants which may be rare in Sussex is *Terebratulina Rowei*; but several specimens have been found, and their relative scarcity is probably due to the absence of clean unbattered surfaces, which alone are favourable for finding so small a fossil.

In the matter of lithological details the upper belt of *O. pilula* offers some strikingly minute correspondences. It is invariably the rule in Hants as it is in Sussex that the lowest 12 to 18 inches are marked off by marl seams, and that the highest 3 feet or so, characterized by *O. pilula* of exceptional size and shape, are marked off by marl seams (with a flint seam almost always about midway).

C. *Zone of A. quadratus.*

All the synclines which have been defined contain as their highest element outliers at least of this zone. In the relatively shallow Rottingdean syncline the outlier is split by Rottingdean Gap into two parts, which occupy the summits of the hills east and west of Rottingdean and are quite inaccessible from the shore; but a fair though scanty section through some of the lower beds is afforded by the road cutting down the east side of East Hill.

At the west edge of the Telscombe syncline there is probably an outlier of this zone on the east slope of Portobello Hill. In the centre of the Telscombe syncline we get the base of the zone descending to some 8 feet below high-tide level, but unfortunately there is no beach here, and so only a small thickness of wave-washed chalk becomes accessible. (It is, however, interesting to note that the 12 feet or so which is accessible agrees most closely in lithological details with the Newhaven and Seaford Head sections.) The deepest part of the syncline is about a quarter of a mile west of Telscombe Stairs. Here the cliff, which is practically solid chalk, just exceeds the 100 feet contour and the top of the zone of *O. pilula* is about 7 feet above low-water mark, so that there must be over 90 feet of the zone of *A. quadratus* preserved. The bed-to-bed thickness of the greater part can only be estimated here but the lower 70 feet can be measured at Telscombe Stairs.

From Telscombe to Newhaven Harbour this zone never ceases to occupy the top of the cliff. In the Castle Hill syncline it comes down almost to beach level (here a few feet above high-water mark). The lower beds are easily accessible (though very dirty) over a long distance, and a considerable thickness, amounting to about 55 feet, is measurable at Burrow Head, while a further 15 feet (about) appears to be preserved at the top of the cliff in the centre of the syncline.

When chalk reappears on the east side of the Ouse Valley at the Buckle Inn it is chalk of this zone which is at the surface and composes the low cliffs immediately round the Buckle Inn. A fair section of probably rather higher beds used to be furnished by a low cliff between here and Seaford, which is now sloped, and hidden in the lower part by a sea-wall.

Finally we come to the Seaford Head section, easily measurable owing to the dip. The full thickness preserved here beneath the

Tertiaries is just about 55 feet, as at Burrow Head, so that there are at least 35 feet of chalk at Telscombe and some 15 feet in the centre of the Castle Hill syncline higher than anything at Seaford.

The following general section will apply to all the chalk of this zone :—

ZONE OF *A. QUADRATUS* IN THE SUSSEX CLIFFS.

	ft.	in.		ft.	in.
Chalk inaccessible at Telscombe, estimated at	30	0			
Chalk measured at Telscombe, inaccessible at Newhaven and only partly preserved at Seaford	19	0			
	49	0		49	0
Strong flint seam.					
Chalk	5	6	to	7	0
Strong flint seam.					
Chalk	6	0		6	6
Strong flint seam.					
Chalk	11	0		13	0
(In the upper part of this bed there may be a thin seam of *O. pilula* at Newhaven, of which there is no trace at Seaford. The Telscombe section affords no test.)					
Strong flint seam.					
Chalk	9	0		10	3
(There are two marl seams in this bed at Telscombe and traces of marl seams at Newhaven, but none at Seaford.)					
Strong flint seam.					
Chalk	6	0		6	0
(There is a thin marl seam just above the base of this bed at Newhaven.)					
Broad seam of loosely set flints.					
Chalk	3	6		5	6
Weak marl seam.					
Chalk	1	6		2	6
Flint seam.					
Chalk	1	0		1	6
	92	6	to	101	3
Marl seam marking top of zone of *O. pilula*.					

Attention is called to the fact that the lowest 3 to 4 feet are marked off by a marl seam and embrace a flint seam. This will be found to be repeated in the Isle of Wight, and it is also the case at Hursley, Compton, and West Meon in Hants, where the bounding marl seam is very faintly marly and little more than a parting. It forms a striking combination with the even more widely constant bed at the top of the zone of *O. pilula* and immediately preceding it.

There is little to be said about the general fauna of the zone, only the lowest beds being in practice accessible for any distance, and these, as I have previously pointed out,[1] being characterized chiefly by the gradual dying out of such of the leading fossils of the subzone of abundant *O. pilula* as succeeded in outliving it. Thus, while

[1] "The proposed recognition of two stages in the Upper Chalk": GEOL. MAG., February, 1913, p. 61.

Terebratulina Rowei and *Echinocorys scutatus*, var. *truncatus*, have disappeared apparently for good, and *Offaster pilula* though theoretically a possibility is in practice absent, the other leading fossils of the subzone of abundant *O. pilula* have lives of varying but probably always brief duration in the base of this zone. *Ostrea canaliculata*, var. *striata*, for instance, is strongly represented in the lowest 6 feet and then apparently disappears completely. *Bourgueticrinus* Forms 1 and 2 continue to occur sparingly for about 12 feet (accompanied by transitions to forms which establish themselves later) and then disappear. [*Bourgueticrinus* Form 3 I think must be withdrawn from the list of characteristic forms of the subzone of abundant *O. pilula*. It is specially abundant in that subzone, but both appears before it and persists in occasional instances long after it, and can only be treated as a subsidiary guide fossil, for which a subzone so strongly characterized has no need.] Mr. Spencer's remarks[1] as to the affinity of giant ossicles of *Metopaster Parkinsoni* and *Calliderma Smithiæ* for the zone of *O. pilula* (*sub nom.* "subzone of *O. pilula*") and the lower beds of the zone of *A. quadratus* (*sub nom.* "subzone of *A. quadratus*") give interest to the question exactly how far up the zone of *A. quadratus* these forms range. The giant ossicles of *Metopaster Parkinsoni* seem to culminate at from 26 to 33 feet; only one has been found yet above this level, i.e. at about 43 feet. They have never yet been found in the upper part of the zone. The large ossicles of *Calliderma Smithiæ* similarly referred to[2] have not been found more than 12 feet up.

The only striking feature is *Hagenowia rostrata*. This fossil sets in as soon as the zone of *O. pilula* has ended and becomes sufficiently abundant to serve as a guide fossil. Unfortunately the body of the urchin is never preserved, the rostra having at most a little film of shell attached. It is interesting to note that a rostrum has recently been found in this zone, apparently for the first time in Hants, at Compton, near Winchester, and in precisely the same relative position in the zone.

Belemnites are very scarce in the zone of *O. pilula* except perhaps at the base, where *A. granulatus* occurs sparingly but fairly consistently. It is therefore only where there is a large area available that there is any prospect of obtaining, even in the course of years, enough specimens to afford any clue to the range of the various species in that neighbourhood. The Sussex coast-section of the zone is the only one which fulfils this condition, and it will not be out of place to give the Belemnites at this point the special consideration which they have earned by their value as zonal guides elsewhere.

Experience prepares us for the occurrence of four Belemnites, *A. granulatus*, *A. quadratus*, *A. verus*, and *Belemnitella lanceolata*. Of these *B. lanceolata* and *A. verus* have not been found yet, except for an imperfect Belemnite at the top of the zone of *E. scutatus*, var. *depressus*, which may have been *A. verus*, and they are only likely to

[1] W. K. Spencer, "The Evolution of the Cretaceous Asteroidea": Phil. Trans. Roy. Soc. Lond., ser. B, vol. cciv, p. 112.

[2] W. K. Spencer, op. cit., p. 218.

occur as isolated curiosities. Interest is therefore concentrated on *A. granulatus* and *A. quadratus*.

All my specimens, not a large number, from the *lower* part of the subzone of *E. scutatus*, var. *depressus*, are too imperfect to be identified; they may with all probability be assumed to be *A. granulatus*, as Dr. Rowe appears to have found at that level Belemnites identifiable as that species, and there is no evidence yet that *A. quadratus* ever ranged so low.

At a point 25 feet below the top of the subzone, i.e. in its upper half, I found a specimen broken but complete except for slight fraying of the edges of the alveolar cavity. Mr. Crick and Dr. Blackmore both regard this specimen as intermediate between *A. granulatus* and *A. quadratus*, Mr. Crick saying "The specimen, although possessing affinities with *A. quadratus*, seems to me to be more closely related to *A. granulatus*"; and Dr. Blackmore saying that it "is, I believe, *A. quadratus*, although the general contour of the specimen is rather like that of *A. granulatus*, but the depth and form of the phragmaconal cavity is that of the former species". That the special features of the specimen are not accidental is shown by the fact that some 4 miles away I found about 6 feet higher in the subzone the upper half of a Belemnite with the alveolar cavity in perfect preservation and agreeing exactly with the specimen submitted to Mr. Crick and Dr. Blackmore. If in South England there occurred a passage from *A. granulatus* to *A. quadratus* synchronous with that which seems to be generally accepted as having taken place on the Continent and likely to be established for Yorkshire by Mr. Stather, the horizon at which that passage took place would appear to be pretty closely fixed by these specimens. (The specimen of *A. quadratus* recorded by me from this subzone in Hants[1] came, as far as I can judge, from a slightly higher horizon in the subzone.) I have found no other identifiable Belemnites in this subzone in Sussex.

In the subzone of abundant *O. pilula* in Sussex I have only found two Belemnites. One of them was found in the upper belt of *O. pilula*, but only the lower end is preserved. It is either *A. granulatus* or *A. quadratus*. The other specimen was found in the *Cinctus* belt; it had already been severely attacked at the upper end, but one side of the alveolar sheath still remained intact, and neither Mr. Crick nor Dr. Blackmore has any doubt as to its being *A. quadratus*. This agrees closely with Hants, where the only Belemnite known from this belt of the subzone is a fine specimen of *A. quadratus*, and where I have recently obtained a fairly certain specimen of that species from the lower belt of *O. pilula*.

In the zone of *A. quadratus* on the Sussex coast I have just obtained a specimen of *A. quadratus* about 8 feet above the zone of *O. pilula*, the first Belemnite I have yet seen in all the chalk of this zone that is accessible.

On the cognate subject of Ammonites, known to occur freely on this coast, it is worth noting that I have seen a great many, all of which were in the zone of *O. pilula*, and all but one in the subzone

[1] *The Stratigraphy of the Chalk of Hants*, p. 11.

of *E. scutatus*, var. *depressus*. The significance of this distribution is not necessarily very great, as specimens are only conspicuous on the foreshore and there is relatively little chalk of the subzone of abundant *O. pilula*, and hardly any of the zone of *A. quadratus* exposed on the foreshore.

(*To be continued in our next Number.*)

REVIEWS.

I.—Earth Folds and Mountain Formation.

1. E. C. Abendanon. Die Grossfalten der Erdrinde. With a preface by Dr. K. Oestreich. pp. x, 183. Leiden, E. J. Brill; London, Dulau & Co.: 1914. £5.
2. K. Andrée. Über die Bedingungen der Gebirgsbildung. pp. viii, 101. Berlin, Gebrüder Borntraeger; London, Dulau & Co.: 1914. Marks 3 Pfg. 20.

THESE two works deal with special branches of geotectonic principles and they have many points in common. They show by the conclusions of their authors and by the extensive literature quoted—the references to which are by no means exhaustive—the steady growth of the belief that the main topographic features of the earth are due to movements of the crust and not to denudation. They both moreover agree in rejecting as a cause that great lateral thrusting to which, in many graphic passages, Suess attributed the behaviour of the land during the elevation of the fold-mountains of Eurasia. E. C. Abendanon, who is well known for his investigations in Mid-China and the Dutch East Indies, in his work discusses the 'Grossfalte' or the great folds of the earth.

'Grossfalte,' according to Abendanon, are broad uplifts due to the sinking of wider surrounding areas. He holds that all the main movements in the crust are vertical. The larger, heavier, stronger blocks sink and thereby force up the lighter, smaller, weaker blocks, which rise in flat swellings wherein the material expands and is under tension. 'Grossfalte' are therefore torn by disruption clefts and broken by rift-valleys, and overthrusting, due to the outward flow of the upraised material, occurs on the edges of these uplifted areas.

The book has a preface by Professor Oestreich, of Utrecht, who cautiously declines to predict whether the term 'Grossfalte' will become naturalized in science. Abendanon's thesis is that the formation of the major folds in the earth's crust is the most important of geological processes. These folds he attributes to vertical movements under the influence of gravity; he denies the great tangential thrusting assumed by Suess, and regards the main folding as caused by the crumpling of the crust during the shrinkage of the earth. The 'great folds' include the subsidence of the crust in geosynclines, its rise elsewhere in geanticlines, and also extensive systems of faults. In consequence of these

movements the material of the geanticlines is cooled, and the rocks in them become hard and brittle; hence when disturbed the uplifted areas are torn by fractures. In the geosynclines, on the contrary, the material is heated and becomes plastic; hence when disturbed it yields by flowing, and, as the material below the geosyncline is compressed laterally while sinking, the hidden materials are intensely crumpled and altered. Fracturing is especially visible on the margins of the geanticlines, and as the central areas are lowered by denudation the anticlinals are exposed as metamorphic blocks. Amongst other consequences of this folding of the crust he includes the distribution of exposed metamorphic areas and former climatic changes; though he does not claim that it has been certainly proved that the glacial climate is due to anticlinal uplift, he believes "that it is the main factor and not improbably the only factor" (pp. 161–2).

In describing the special regions of 'Grossfalte' he begins with the Malay Archipelago; he claims that the movements there are independent of the pre-Tertiary structure. The movements began, he says, in the Neogene and were continued more briskly in the Pleistocene; they produced rift-valleys and sunklands as well as folds and were associated with powerful volcanic eruptions. Among European 'Grossfalten' he describes the rift-valley of the Rhine, the Phocene dislocations of the Juras, the Pleistocene uplift of the Alps (proved by Penck for at least 400 metres), the pre-Glacial but young folding of Scandinavia, and the many important recent earth-movements in the Balkans and the Ægean. He favours the tectonic origin of Alpine lake-basins and attributes the long strike valleys of the Alps to tension clefts (Distraktionsrissen).

In America he describes the St. Lawrence as a recently foundered valley and more striking examples from Western America, where since the Quaternary there have been two great Falten. The eastern began in the Neogene and was enlarged in the Quaternary, while the western happened entirely in the Pleistocene. In Africa the Great Rift Valley and Madagascar supplies the author's chief examples. He therefore holds that all the continents have been greatly affected geographically by movements of recent age; although these disturbances are almost worldwide in distribution, he recognizes no regularity in their arrangement (p. 160). He attributes to them the determination of the main relief of the lithosphere, both submarine and terrestrial; and though he remarks that its genesis dates from the pre-Palæozoic, he holds that the present surface features of the earth are very young in age. Theories of the permanence of oceans and continents he apparently regards as unworthy of discussion.

Dr. K. Andrée, of Marburg, discusses the conditions of mountain formation. He belongs to the same school as Abendanon. His book is divided into three main sections; the first considers various theories of mountain formation, especially those dealing with the contraction and shrinking of the earth, the tetrahedral theory, the gliding theory of Reyer, and various thermal or expansion theories. He rejects the theories of the simple contraction and of tangential thrusting.

He objects to the original tetrahedral theory on the ground that radioactivity has rendered it uncertain whether the earth is growing cooler; but he quotes with approval the modification of the tetrahedral theory advanced in 1899. He regards with most favour the explanation that the great mountain chains are connected with geosynclinal subsidences and with the gliding of the adjacent areas under the influence of gravity. In the second part of his book, having cleared the ground by his preliminary discussions, he considers how mountains can be explained without invoking tangential pressure. He advocates the view that subcrustal flow is the main agency in mountain formation. This conclusion was advanced by Ampferer, and Dr. Andrée warmly supports it and discusses its relations to isostasy, the distribution of gravity, the structure and course of mountain chains, the distribution of the Atlantic and Pacific lavas, and the types of earthquakes classified as fracture-earthquakes and fold-earthquakes. In his third section he considers the evidence for the uplift of some areas into mountain chains at the present day, and refers especially to that suggestion in regard to the meridional ridge along the mid-Atlantic. He discusses the deep-sea material obtained by the German Antarctic Expedition and its discovery of continental sands on the floor of the South Atlantic, but he does not accept the view that the mid-Atlantic ridge has been proved to be a rising mountain chain. Like Abendanon he believes in the periodicity of movements in the earth's crust with an alternation of epeirogenetic and orogenetic movements.

Both books are valuable contributions to the study of the formation and distribution of the major features in the relief of the earth.

J. W. G.

II.—A Geological Map of the Caucasus. By Felix Oswald, D.Sc., B.A., F.G.S., F.R.G.S. With Explanatory Notes. London: Dulau & Co., Ltd., 1914. Price 15*s.* net.

DR. FELIX OSWALD is already well known in the geological world by his treatise on *The Geology of Armenia*, published in 1906 (8vo, pp. ix, 516, with maps, plates, and sections), reviewed in the Geological Magazine, 1906, pp. 562–3.[1] The map now published has been compiled from the latest sources and is produced in colour on the scale of 1 : 1,000,000 or 15·78 miles to the inch. In the accompanying pamphlet of sixteen pages the author deals first with the general structure of the range, he then gives an account of its evolution, followed by an outline of the geological succession.

[1] In connexion with this map of Armenia it may be of interest to record that Sir Archibald Geikie, when President of the Geological Society of London, February 15, 1907, presented the "Murchison Geological Fund" to Dr. Felix Oswald (awarded to him by the Council), in recognition of the value of his contributions to our knowledge of the geology of Armenia in the remarkable volume then recently published. A further note on Dr. Oswald's work on the geology of Armenia will be found in the Geological Magazine for 1910, p. 283.

The chain of the Caucasus falls naturally into three main divisions: (1) the Central Caucasus, between Elburs and Kazbek; (2) the Western Caucasus, from Elburs westward to the point where the main axis runs into the Black Sea; (3) the Eastern Caucasus, from Kazbek to a point where the main axis runs into the Caspian. There are areas of Recent and Middle Tertiary beds (well-known to contain petroleum) at either end of the chain, which are characterized by the presence of mud-volcanoes. The western or Taman district lies in the north, while the eastern or Apsheron district lies to the south of the main axis.

The Central Caucasus is not only the loftiest part of the chain, but erosion has carved out such deep valleys that the structure is here most clearly revealed; its delimitation by Elburs (18,523 feet) and Kazbek (16,546 feet) is no arbitrary selection, but the natural expression of tectonic structure, for these volcanic masses lie on two transverse N.–S. fractures along which volcanic activity has been very pronounced, while they are still the seat of violent earthquakes.

The Western Caucasus becomes progressively simpler in structure, the core of gneiss and crystalline schists disappearing at Fisht beneath a cover of Jurassic and Cretaceous deposits; the main axis then diminishes rapidly in height, from over 9,000 to less than 3,000 feet, and consists for the last 200 miles of its course of only Upper Cretaceous strata.

The Eastern Caucasus, on the other hand, widens out to 140 miles in Daghestan. This district is essentially a succession of parallel chains in the south; but the northern part is a wide undulating plateau of Jurassic and Cretaceous beds.

The Daghestan plateau is broken off on the east by a nearly meridional line of fracture, a fall of 12,000 feet being thereby produced in a distance of only 10 miles. A fracture of similar magnitude parallel to the main axis delimits the Eastern Caucasus along its southern side, and at the point of intersection of these two great fractures the basalts and andesites of the Nial Dagh have been erupted, mineral springs occur, and earthquakes are frequent.

The account of the evolution of the Caucasus is of much interest. The main axis in the central division consists of gneiss, flanked by crystalline schists, which have been acutely folded into a geanticline displaying fan-structure, so that the schists dip beneath the gneiss and overlie in turn the reversed Palæozoic schists. The upraising of the Caucasus in the Permian period continued into the Trias,[1] excepting in the western division, which was partly covered by the waters connecting the Alpine sea with the Armenian and Indian seas. In the Lower and Middle Jurassic periods there was extensive submergence with oscillations allowing the local formation of coal. Intense folding again took place in the Upper Jurassic, with a Tithonian transgression on the north of the chain. The chief and

[1] In 1907 an important addition was made by the Russian geologist Mr. J. Worobiev to our knowledge of the geology of the Caucasus by the discovery of beds of Upper Triassic age on the Little Laba River at Psebai, and along the Khods River. Dr. Oswald gives an account of this in the GEOLOGICAL MAGAZINE for 1909, pp. 171–3.

latest period of folding took place after the deposition of the Middle Miocene (Sarmatian). The Central Caucasus was raised to its present height, its folds pinched in to become fan-folds, and the transverse fractures were developed on which Kazbek and Elburs built up their huge piles of lava.

The different formations are described and lists of their included fossils are given. The Quaternary and Recent deposits include Coast deposits of the Caspian up to 10 metres above the present level, Old Caspian and Black Sea deposits up to 26 metres, and the Aralo-Caspian Stage with terraces at 96 and 186 metres.

In the Pliocene the Pontian division contains gas in the Apsheron Peninsula. The Miocene and Oligocene beds yield much petroleum. The Cretaceous and Jurassic are well developed, and an outline is given of their stratigraphy. Basal conglomerates of the Jurassic lie unconformably on the eroded surface of the Palæozoic schists, of which they contain pebbles.

Triassic beds occur in the Western Caucasus, in the upper basins of the Bielaya and Little Laba Rivers, unconformably overlying Upper Carboniferous. The Palæozoic schists are probably in the main of Carboniferous age, though some may possibly be Silurian. A description is given of the main divisions of the igneous rocks which occur, and a note on the glaciers concludes the pamphlet.

Dr. Oswald's work is of the greatest value, and must form the basis of all future explorations in this most difficult but remarkably interesting country.

III.—Summary of Progress of the Geological Survey of Great Britain and the Museum of Practical Geology for 1913. 8vo; pp. 107. Dulau & Co., 1914. Price 1*s*.

THIS number of the *Summary of Progress* shows the interesting nature of the work which has been accomplished during the past year and the large number of new and important facts which that work has brought to light.

The record of field-work is condensed into seventy pages. It is arranged as usual according to the different districts in which work has been prosecuted.

In England and Wales we find that in the Denbighshire district the surveying has been carried southwards into Shropshire, while the part of Cheshire included in the district has been completed and some further colliery information alone remains to be gathered in Flintshire. The Corwen-Glyn Grit has proved a valuable guide in disentangling the structure of the Ordovician rocks, but it has been found difficult to separate the Llandovery and Tarannon Beds, though the presence of both is proved by the graptolites. The examination of the Carboniferous Limestone escarpment south of Llangollen has been finished, and in Flintshire some sandstones hitherto regarded as Lower Coal-measures are now proved to be Millstone Grit. In Cheshire the survey of the peninsula of Wirral is now complete, and a commencement has been made on the deeply drift-covered Triassic area near Oswestry.

In the Warwickshire and Staffordshire district the mapping of the Etruria, Halesowen, and Keele groups has been continued south of Nuneaton, and a thin band of *Spirorbis* limestone known as the Index Bed, which occurs about 150 feet below the top of the Halesowen group, has been traced for a considerable distance. Above the Halesowen group there are upwards of 2,500 feet of sandstones with conglomerates and marls, and there is as yet no evidence to show whether any part of them can be assigned to the Permian. The Arden Sandstone group in the Keuper Marl has been traced for some distance, and the relation of the North Sea and Irish Sea drifts has been further investigated.

In the London and south-east district the surveying of the Chalk has progressed on both sides of the Thames, and the fauna of the horizon of *Heteroceras reussianum* has been proved to have a wide extent. The drifts and Tertiary beds have received much attention, and further light has been thrown, by the mapping, on the faults and folds which affect the strata underlying London.

In Scotland work has been carried on in the Highlands, principally in the counties of Sutherland, Ross, and Argyll. Further evidence of the former extension of the Middle Old Red Sandstone over the Northern Highlands has been obtained by the discovery of a considerable area of conglomerate and red grits 2 miles south of Loch Gaineamhach in Sutherlandshire. In North-Western Ayrshire the new base-line that has been adopted for the Lower Carboniferous is drawn above a series of reddish sandstones that are relegated to the Upper Old Red Sandstone, and revision of the original survey of the Carboniferous districts has also proceeded in the Paisley district and around Hamilton in Lanarkshire. It has proved possible to correlate the results of the geological mapping of the Carboniferous Limestone areas in Lanarkshire, Renfrewshire, and Ayrshire. Small patches of Jurassic rocks, in addition to those previously recorded, have been found in several places underlying the Tertiary lavas of Mull. It has been decided to make a more detailed investigation of the palæontological zones of the island of Raasay on account of the importance of the iron-ore deposits of that island. Here and in Skye an extensive deposit of oil-shale has been found which may prove to be of considerable economic importance. The mapping of the interior of Mull has been continued and has yielded interesting results.

During the year important petrographical and palæontological work has been carried out in connexion with the field-work in both England and Scotland.

Lists of additions to the museum and library are given. In the museum temporary exhibits have been arranged to illustrate the memoir on the geology of the Lizard district and the types of flint implements found at Swanscombe, Kent. There is also a list of maps and memoirs issued during the year. There are three appendices: (1) On the Heswall Boring, by Dr. Strahan; (2) On a Boring for Coal at Hemington, Somerset, by T. C. Cantrill and J. Pringle; and (3) Additional Notes on the Geology of the Lothian Shale-field, by R. G. Carruthers.

IV.—Diamonds in British Columbia.[1]

HITHERTO the only recorded occurrence of diamonds in their original matrix in North America has been that of Pike County, Arkansas, where they occurred in a peridotite. These were discovered in 1908, and during the following year 700 commercial diamonds were obtained. Considerable scientific interest therefore attaches to the discovery, by Mr. R. A. A. Johnston, mineralogist to the Canadian Survey, of small diamonds in chromite segregations in the peridotite of Olivine Mountain in the Tulameen district. The peridotite of Tulameen shows on analysis close similarity with the diamond-bearing peridotite of Arkansas, and both are closely related to the 'kimberlite' of South Africa. The diamonds occur as small octahedra associated with the chromite, towards which they are idiomorphic; and as small spherical patches of a yellowish colour, apparently consisting of aggregates of small particles occurring in veinlets in the chromite. The largest individuals obtained are described as about the size of an ordinary pin's head, but in many cases these individuals break up into small particles within a few hours of being freed from their matrix. Hitherto no diamonds have been found in the gold-placers of the district. It appears clear that the chromite which always accompanies the diamonds is an original constituent, and crystallized later than the octahedral diamonds. The peridotite is intrusive through a series of rocks containing little or no carbonaceous matter, so that it is probable that the carbon existed as an original constituent of the magma.

V.—Canada.

DEPARTMENT of Mines. From the Mines Branch we have received: the Annual Report on the Mineral Production of Canada for 1912, Preliminary Report on the Mineral Production of Canada for 1913 and a paper on the "Preparation of Metallic Cobalt by the Reduction of the Oxide", by H. T. Kalmus and others (1913). The latter publication forms part i of the researches on cobalt and cobalt alloys conducted at Queen's University, Kingston, Ontario, for the Mines Branch.

From the Geological Survey Branch we have Memoirs 23, 25, 26, 30, 37, and 44, with the accompanying maps.

Memoir 23. *Geology of the Coast and Islands between the Strait of Georgia and Queen Charlotte Sound, British Columbia.* By J. A. Bancroft. pp. 146, with 6 figures in the text, 17 plates, and 1 map. 1913.—Although this is to be regarded as a preliminary report, it contains much material of great scientific interest. Those interested in physical geology will find many valuable observations on fiords and hanging-valleys, with a discussion of their origin. The petrography of the igneous rocks of the Coast Range and of the regional and contact metamorphism of the stratified rocks is treated in detail. The plutonic rocks occur in the form of large batholiths. These have been dissected to considerable depths by the fiords, and the

[1] *Geology and Mineral Deposits of the Tulameen District, British Columbia.* By Charles Camsell. Canada, Department of Mines, Geological Survey, Memoir No. 26, pp. 146–53.

sections afford many opportunities for discussing the methods by which the overlying strata are invaded. The phenomena observed are found to corroborate the theory of "overhead stoping" advanced by Daly.

Memoir 25. *Report on the Clay and Shale Deposits of the Western Provinces.* By A. Ries and J. Keele. pp. 99, with 6 figures in the text and 40 plates. 1913.—The first report on this subject was published as Memoir 24 E. The present memoir is devoted almost entirely to technical detail; it shows the extension of several useful types of clay discussed in the earlier publication.

Memoir 26. *Geology and Mineral Deposits of the Tulameen District, British Columbia.* By C. Camsell. pp. 188, with 2 figures in the text, 23 plates, and 4 maps. 1913.—This memoir contains some interesting petrography dealing with igneous rocks of Jurassic and of Tertiary age, one notable point being the discovery that the Otter granite, a large batholithic mass, is of post-Oligocene age. The occurrence of platinum in this district has been discussed by Professor J. F. Kemp, whose results have been confirmed by recent observations. The most valuable scientific discovery is that of diamonds occurring in chromite segregations in a peridotite. This is discussed more fully in a separate brief notice above (see p. 375).

Memoir 30. *The Basins of Nelson and Churchill Rivers.* By W. McInnes. pp. 146, with 19 plates. 1913.—The area dealt with in this memoir lies between the Saskatchewan River and Hudson Bay, a district which has been traversed by traders and explorers since 1697. Part of the region was explored by Sir John Franklin's first expedition in 1819–21. The memoir embodies the work of several officers of the Geological Survey between 1877 and 1910. The general geology deals with the early pre-Cambrian rocks, which form the central complex of the region, and with the overlying sedimentary beds, which range from Upper Huronian to Upper Cretaceous. Detailed descriptions are given of the rivers and lakes. Large areas are covered by lacustrine clays belonging to the age of the declining glaciers, some of these occupying an extension of the glacial Lake Agassiz described by Upham in 1888.

Memoir 37. *Portions of the Atlin District, British Columbia.* By D. D. Cairnes.—This is the subject of an earlier notice in this journal (1914, p. 129).

Memoir 44. *Clay and Shale Deposits of New Brunswick.* By J. Keele. pp. 94, with 7 figures in the text, 16 plates, and 1 map. 1914.—In addition to much useful technical information this memoir contains a brief discussion of the origin of clays and shales which will serve as a useful introduction to those interested in the subject.

VI.—Geological Literature added to the Geological Society's Library during the year ended December 31, 1912. 8vo; pp. 268. London: Geological Society, 1914. Price 2*s*.

THIS invaluable publication has now reached its nineteenth year. It is somewhat late, owing to the change of Librarians and consequent dislocation of business entailed, and it is more bulky

owing to omissions in the last volume necessarily made up in this. Several improvements have been made, notably in the attempt to give bibliographic exactness to authors' names and in having a more definite plan in the Index. It is not too much to say that the publication reflects the highest credit on the new Librarian, Mr. C. P. Chatwin. Few people realize the incredible labour it is for one man to compile such a book, with the pressing duties of a library and its visitors to contend with, even when assisted by a competent junior, and we must all feel profoundly thankful that in this volume we recognize that the most valuable publication of the Geological Society of London has entered on a new lease of life with renewed vigour. It is by far the best Record of Geological Literature that is published, and is as useful to the amateur as to the professional.

VII.—Brief Notices.

1. The Crust of the Earth.—The crust of the earth comes in for a good deal of study in the *Journal of Geology*, vol. xxii, No. 2, 1914. W. H. Hobbs continues his papers on the mechanics of formation of Arcuate Mountains, Joseph Barrell continues his on the strength of the earth's crust by writing on "The Regional Distribution of Isostatic Compensation", and T. C. Chamberlin continues the diastrophism and the formative processes by "The Testimony of the Deep-sea Deposits". Important preliminary results of measurements of the Rigidity of the Earth are contributed by A. A. Michelson. The first and last papers are well illustrated and can be easily followed.

2. Lancashire and Cheshire.—The Proceedings of the Liverpool Geological Society, vol. xi (4), 1913, contain papers of markedly local interest. Excavations at Liverpool and Birkenhead have been watched and recorded by C. B. Travis and T. A. Jones, and plants and other remains are recorded from Seaforth. W. T. Walker writes on the Boulder-clay of North Wirral, and H. C. Beasley describes the Storeton find of 1912 and reproduces Morton's map of the faults in the Storeton area. Numerous references occur throughout to the variety of rocks found in the Lancashire-Cheshire Boulder-clay, but we do not remember any special paper dealing with the subject which would probably be worth working up.

3. Chalk of Suffolk.—Mr. P. G. H. Boswell has given a sketch of the Chalk of Suffolk in the Journ. Ipswich Field Club, vol. iv, 1913. He records the successive zones from that of *Belemnitella mucronata* to *Holaster planus*, and although he does not give a list of his fossils, the few he quotes are sufficiently convincing. The thickness of Eocene beds to the east and south of the county may hinder the publication of a zonal sketch-map of the county, but Mr. Boswell's paper is based on field work and personal observation and will be a sufficient guide to any one familiar with the Chalk and its fauna, especially when read in conjunction with his paper "On the Age of the Suffolk Valleys" issued in vol. lxix of the Quarterly Journal of the Geological Society, 1913 (1914).

REPORTS AND PROCEEDINGS.

I.—The Royal Society.

June 18, 1914.—Sir William Crookes, O.M., President, in the Chair.

Among other papers read was the following :—

"A Description of the Skull and Skeleton of a peculiarly modified Rupicaprine Antelope, *Myotragus balearicus* (Bate)." By Dr. C. W. Andrews, F.R.S.

Myotragus balearicus (Bate) is a peculiarly modified rupicaprine antelope, remains of which were discovered by Miss D. M. A. Bate in cavern deposits in Majorca and Minorca (see *ante*, pp. 337–45).

The dentition is very remarkable. Instead of having three incisors and a canine on each side of the mandibular symphysis as is usual in the Bovidæ, the canines and the two outer pairs of incisors are wanting, while the median incisors are enormously enlarged rodent-like teeth, growing from persistent pulps. The premolars are reduced in number and the molars have very high crowns.

The feet are remarkable for the shortness and stoutness of the metacarpals and metatarsals, which are quite similar to those of the Takin (Budorcas). The animal seems to have been adapted for climbing on steep crags and cliffs, and probably lived on very hard vegetation. A full account of the osteology and dentition is given in the paper.

II.—Geological Society of London.

June 10, 1914.—Dr. A. Smith Woodward, F.R.S., President, in the Chair.

The following communication was read :—

"The Ballachulish Fold near the Head of Loch Creran (Argyllshire)." By Edward Battersby Bailey, B.A., F.G.S.

The district of Lower Glen Creran has recently been much more carefully examined than heretofore. The course of the Ballachulish Fold had already been determined with approximate accuracy. The purpose of the present paper is to draw attention to two phenomena strikingly illustrated by the local evidence :—

(1) The complexity of the slides affecting the Ballachulish Core, and the correlated (quite exceptional) occurrence of more groups towards the close of the fold, south-east of the River Creran, than towards the gape, north-west of the same.

(2) The intense secondary refolding of the Ballachulish Fold, and the resultant sinuous outcrop of the Ballachulish Core.

Dr. Douglas Mawson gave an account of the geology and glaciation of the Antarctic regions, as observed in his recent expedition, and exhibited a series of magnificent lantern-slides, many of which reproduced the natural colouring by direct photography. A unanimous vote of thanks, proposed by the President and seconded by Dr. J. J. H. Teall, was tendered to Dr. Mawson, by whom it was briefly acknowledged.

June 24, 1914.—Dr. A. Smith Woodward, F.R.S., President, in the Chair.

The following communications were read:—

1. "The Paradoxidian Fauna of a part of the Stockingford Shales." By Vincent Charles Illing, B.A., F.G.S.

This communication deals mainly with a small subdivision of the Stockingford Shales occurring at the base of the Oldbury division. The beds have been termed the Abbey Shales, and are about 100 feet thick, consisting mainly of blue laminated shales, although glauconitic sandy horizons occur at frequent intervals. This small subdivision passes down into the Purley Shales, while it is separated from the overlying shales (which are probably of Lower Maentwrog age) by a calcareous conglomerate lying upon an eroded surface of the underlying blue shales, although the irregularity of the eroded surface does not appear to be great in the somewhat poor exposures.

The beds have been examined in a series of trenches situated near the Abbey Mound in Hartshill Hayes, and have yielded over fifty different species of Trilobites—each ranging through one or more of about fifteen fossiliferous horizons in the sequence. The fauna shows marked affinities with those of the equivalent beds in Wales, Scandinavia, and Bohemia, and the following subdivision into zones has been attempted:—

Horizon.	
G 3–G 1	Upper *davidis* fauna.
F 3–F 1	Lower *davidis* fauna.
E 3–E 1 (*pars*)	*Hartshillia* fauna.
E 1 (*pars*)–D 1	Upper *hicksii* fauna.
C 3–B 1	Lower *hicksii* fauna.
A 4–A 1	*P. aurora* fauna.

The importance of the Abbey Shales lies in the possibility which they afford of a close correlation between the Swedish and British Paradoxidian faunas, for the intermediate geographical position is accompanied by an intermediate type of fauna forming a link between these two well-known areas.

The following is a brief summary of the correlation which appears to agree best with the available evidence:—

South Wales.	Hartshill.	Scandinavia.	
P. davidis zone.	Upper *P. davidis* fauna.		
	Lower *P. davidis* fauna.	*P. davidis* zone.	
	Hartshillia inflata fauna.	*Ct. æqualis* subzone.	*P. tessini* zone.
P. hicksii zone.	Upper *hicksii* fauna.		
	Lower *hicksii* fauna.	*Agnostus parvifrons* subzone.	
P. aurora zone.	*P. aurora* zone.	*Ct. exsulans* subzone (*pars*).	

In addition, the evidence suggests that the Upper Purley Shales correspond to the rest of the *Ct. exsulans* zone and also the *P. ölandicus* zones of Sweden.

The Abbey Shales appear to have been deposited in rather a shallow sea, in which slight changes in conditions introduced marked variations in the rock-types. Corresponding to these alternating physical conditions there occur alternations of faunas—a good example being afforded by *Agnostus rex*, found in the coarse shales, and *A.* (*Ct.*) *intermedius*, found in the blue shale.

Towards the close of the Middle Cambrian Period excessive shallowing of the water introduced a period of marine erosion—causing a break in the sedimentary sequence with the elimination of the equivalents of the *P. forchhammeri* zone, and in some cases a portion of the *P. davidis* zone. This break appears to have extended over a large part of Great Britain. Attention is drawn to the fact that none of the characteristic forms which occur exclusively in the rich *P. forchhammeri* zone of Scandinavia have been noted from any locality in Great Britain.

2. "The Trilobite Fauna of the Middle Cambrian of the St. Tudwal's Peninsula (Carnarvonshire)." By Tressilian Charles Nicholas, B.A., F.G.S.

In a previous paper on the geology of the St. Tudwal's Peninsula approximate determinations were given of the fossils found in the Upper Caered Mudstones and Nant-pig Mudstones, both of Middle Cambrian age. The object of the present paper is to give detailed descriptions of several forms which are either new or of particular interest: namely, *Agnostus kjerulfi*, two new species of *Agnostus*, a species of *Agraulos*, of *Dorypyge*, of *Corynexochus*, and *Solenopleura applanata*, and to give brief notes on a number of other species, including *Agnostus punctuosus*, *A. exaratus*, *A. fissus*, *A. altus*, *A. truncatus*, *Microdiscus punctatus*, *Conocoryphe* cf. *dalmani*, and *Paradoxides hicksii*.

The vertical distribution of the different forms through the Upper Caered and Nant-pig Mudstones is tabulated and compared with that of other areas, particularly the succession recently established by Mr. V. C. Illing in the Abbey Shales of Nuneaton. This comparison strengthens the opinion already put forward in the previous communication, that there is a non-sequence at the base of the *Lingula* Flags in the St. Tudwal's Peninsula.

III.—Mineralogical Society.

June 16, 1914.—Dr. A. E. H. Tutton, F.R.S., President, in the Chair.

Dr. J. Drugman: Childrenite from Crinnis Mine, Cornwall, and Eosphorite from Poland, Maine. Analysis of childrenite from Crinnis Mine showed it to contain even less manganese than the specimens from George and Charlotte Mine. Eosphorite from Poland is richer in manganese than that from Branchville, the only occurrence previously known. It is well crystallized, unlike the Crinnis Mine childrenite. — R. H. Solly: On Sartorite. From a geometrical examination of 200 crystals it is concluded that Dr. Trechmann's crystals, Nos. 1 and 2, belong to a new species closely allied to sartorite and smithite. Many new forms for sartorite were found.—

Dr. G. T. Prior: Re-determination of Nickel in the Baroti and Wittekrantz Meteorites. Precipitation with ammonia was found not to separate iron from nickel completely, however often the operation was repeated. Re-determination showed that the proportion of iron to nickel in the case of both the meteorites in question was nearer 6 : 1 than 10 : 1 as previously stated.—Dr. L. L. Fermor: Ice Crystals from Switzerland. Last winter the surface of the snow in shady situations near Zweisimmen and Lenk was often characterized by a dense growth of hollow prisms formed of a thin shell of ice coiled spirally parallel to the face of a hexagonal prism.—Dr. L. L. Fermor: Hematite from the Kallidongri Manganese Mine, India. The crystals, which had the habit of corundum and were marked with three sets of striations due to twin lamellation parallel to 100, showed the forms 111 and 61$\bar{4}$ well developed, together with $\bar{1}$00, 22$\bar{1}$, 28.28.13 (a new rhombohedron), 51$\bar{3}$, 71$\bar{5}$, and 10$\bar{1}$ less prominent.—H. B. Cronshaw: A variety of Epidote from the Sudan. A mineral discovered by Mr. G. W. Grabham in a pegmatite vein closely resembles allanite in appearance, but is free from rare earths and agrees in composition with epidote; in its pleochroism and negative sign it also resembles the latter, but has an abnormally low optic-axial angle of about 54 degrees. In thin section it represents a well-marked zonal structure.

CORRESPONDENCE.

SATURATION OF MINERALS AND GENESIS OF IGNEOUS ROCKS.

Sir,—The separation of the different mineral components of an igneous rock is so complex a question that it requires a careful study of each individual rock type, with every effort to follow the different vicissitudes to which it has been subjected from its original state of a homogeneous, vitreous paste, through its magmatic differentiation till its final cooling, not to speak of subsequent changes. In the vast majority of somewhat ancient rocks that are only exposed by erosion the time occupied by this may represent very considerable changes subsequent to complete consolidation.

I fully agree with Mr. A. Scott[1] in his protest against the classification of rocks independent of their 'cooling history', or, to put it more correctly, he agrees with me! The American classification of rocks I look upon as many steps backwards by this introduction of a cumbersome nomenclature and diagrams, interesting perhaps to the chemists, but murderous to the true naturalist or geologist. It hides the beautiful forms of geological phenomena under a gaudy patchwork mantle of mostly untenable hypotheses spangled with fantastical names. I say that Mr. A. Scott agrees with me, for, if he will consult the papers quoted below,[2] he will find himself forestalled in

[1] See Geol. Mag., July, 1914, pp. 319–24.

[2] "Geology of Vesuvius and Monte Somma": Q.J.G.S., vol. xl, pp. 35–119, 1884. "Some Speculations on the Phenomena suggested by a Geological Study of Vesuvius and Monte Somma": Geol. Mag., Dec. III, Vol. II,

many facts marshalled by him in his discussion of Professor Shand's paper in the GEOLOGICAL MAGAZINE.[1]

It is for nearly thirty years now that I have been preaching the same sermon—the 'cooling history' or, as I prefer to call it, the 'vicissitudes of consolidation', which I may sum up under the following heads:—

1. Primary composition of the paste.

2. Additions, or rather acquisitions, to it in its progress from its source to its final position: (*a*) assimilation of materials from its enclosing rock, (*b*) materials brought to it with the assimilation of saline solutions, gases, etc., otherwise *endosmotic* metamorphism.

3. Losses from it in its progress from its source to its final position: (*a*) abandonment of materials to its enclosing rock, (*b*) losses of soluble materials to fluids circulating in its vicinity, or losses of volatile constituents escaping by pores, fissures, or a chimney opening to the atmosphere, etc., otherwise *exosmotic* metamorphism.

4. Rate of cooling or interruptions of cooling: (*a*) to surrounding rocks, (*b*) loss in the acquisition of H_2O or other materials, volatile or otherwise, (*c*) conduction by surrounding rocks, (*d*) evolution of volatile materials, (*e*) vesiculation, or the conversion of volatile materials from the volume of a liquid dissolved in a liquid to the state of a gas, (*f*) ebullition and sublimation of volatile materials by fumaroles or an open volcanic vent.

5. Diminution, rapid or slow, and other vicissitudes of pressure.

I was able to show that, of the sister minerals, orthoclase was formed under high pressure, whilst leucite was individualized under low pressure and principally at an open volcanic vent, as exhibited by the large crystals of leucite growing over big plates of sanidine. The same was shown with regard to amphibole and augite. Furthermore, the presence of small quantities of some bodies that have been called mineralizers, but may well be called catalyzers, may be added to my list of 'vicissitudes of consolidation'.

What determines, for instance, in low-pressure minerals, the final separation of the three felspathoids, leucite, haüyne, or noscan, all of which appear in almost identical conditions in the lavas of Monte Vultura and other localities? Why do abyssal minerals, such as amphibole, sommite, biotite, and, I can lately add, garnet, be deposited under practically no pressure in the loose pipernoid tuffs of the Campania? I have specimens of bones of *Cervus elaphus* (which I have described) covered with crystals of amphibole and a nepheline mineral (sommite or micro-sommite) and biotite, which must have been deposited at so low a temperature that even now the gelatinous constituent of these bones has not been carbonized, but, by heating over a flame, can be blackened yet covered, as such specimens

pp. 302–7, 1885. "The Relationship of the Structure of Igneous Rocks to the Conditions of their Formation": Sci. Proc. R. Dublin Soc., N.S., vol. v, pp. 112–56, 1886; see also Q.J.G.S., vol. xli, pp. 103–6. "On the Fragmentary Ejecta of Volcanoes": Proc. Geol. Assoc., vol. ix, pp. 421–32. "The Causes of Variation in the Composition of Igneous Rocks": Nat. Sci., vol. iv, pp. 134–40, 1894.

[1] See paper by Professor S. J. Shand in GEOL. MAG. for 1913, pp. 508–14.

are, by a crust of these silicates.[1] In this case there is no doubt that fluorides contained in the tuff magma were the catalyzers or mineralizers.

When we have solved all these problems, then will be the time to institute a true classification of rocks and their mineral constituents, but until then any of the recent attempts to do so only hide our ignorance under a cloud of fantastic but unfounded generalizations. The 'saturation of minerals' is, I contend, more accurately represented by my 'principle of fraction exhaustion'.

H. J. Johnston-Lavis.

Vittel (Vosges), France.
July 16, 1914.

OBITUARY.

Rev. OSMOND FISHER, M.A., F.G.S.,

Hon. Fellow and late Tutor of Jesus College, Cambridge.

Born November 17, 1817. Died July 12, 1914.

So lately as last June we claimed our dear and valued friend, the Rev. Osmond Fisher, as one of the four surviving contributors to the opening volume of the Geological Magazine in 1864, and now in August we have to record his loss. He passed peacefully away on Sunday, July 12, after an honourable and useful life of 97 years, retaining his faculties active until the end.

Those who *knew* him need no record of his worth; for the younger generation of geologists, we may refer them to his life and portrait which appeared in the Geological Magazine for February, 1900, pp. 49–54.

From a very early age Osmond Fisher displayed a keen interest in geology, and was an assiduous collector of fossils in Dorset and Wilts. When at King's College he attended lectures by Lyell and Daniell and visited the galleries of the British Museum. He entered Jesus College, Cambridge, in 1836, taking up mathematics, in which he graduated as 18th Wrangler in 1841. Whilst at Cambridge Fisher attended Sedgwick's lectures and soon a warm friendship followed, and later on, in 1852, Sedgwick proposed Fisher as a Fellow of the Geological Society.

Besides the numerous papers which Osmond Fisher communicated to the Geological Society, the Philosophical and the Geological Magazines, the British Association, and elsewhere, he published a most important work, *The Physics of the Earth's Crust*, to which subject he devoted fully thirty years of his life, and expended the best efforts of his mathematical powers to perfect.

The Geological Society, always anxious to welcome the contributions of mathematical geologists, awarded him the 'Lyell Fund' in 1887, and the Murchison Medal in 1893; but the crowning recognition of his life's work, the award of the Wollaston Gold Medal, did not take place until 1913, probably owing to the retirement in

[1] "On the Formation at Low Temperatures of certain Fluorides, Silicates, Oxides, etc., in the Pipernoid Tuff of the Campania": Geol. Mag., Dec. IV, Vol. II, pp. 309–13, 1895.

which Mr. Fisher remained for so many of his latter years, and to the vast number of younger geologists occupying the stage, amongst whom this illustrious early worker was for a time overlooked.

Mr. Fisher was elected an Honorary Fellow of King's College, London, in 1878, and of Jesus College, Cambridge, in 1893. His portrait was subsequently painted and placed in the Hall of Jesus College.

Sir JOHN BENJAMIN STONE, Knt.,

J.P., F.S.A., F.G.S., M.P. for East Birmingham 1895–1909, High Steward of Sutton Coldfield.

Born February 9, 1838. Died July 2, 1914.

Although most widely known and recognized as the "Prince of Photographers", and during fourteen years as Conservative M.P. for East Birmingham, Sir Benjamin Stone was remarkable as a tireless traveller, having visited Japan, China, British Columbia, Vancouver and the Rocky Mountains, the West Indies, the River Amazon, the Straits Settlements, Asia Minor, Europe generally, and Egypt specially.

He was an accomplished antiquary and enriched the places he visited by his remarkable photographic records. He wrote accounts of his travels in Japan, Brazil, Spain, and Norway, and made the photographic history of the Houses of Parliament, of Westminster Abbey, the Tower, Windsor Castle, St. James's Palace, Lichfield Cathedral, and Sutton Coldfield, of which last place he was five times Mayor and was the founder of its celebrated Vesey Club.

Some years since Sir Benjamin Stone commenced to photograph the most interesting objects preserved in the British Museum (Natural History), Cromwell Road. One of these, representing the complete skeleton of *Diprotodon australis* (reconstructed in part from remains in the Natural History Museum, but chiefly from skeletons discovered by Dr. E. C. Stirling, F.R.S., at Lake Callebonna, South Australia), forms the subject of Plate XV in the Geological Magazine, Dec. V, Vol. VI, pp. 337–9, August, 1907, in illustration of an article by Dr. Arthur Smith Woodward, F.R.S. Among his geological photographs is one taken of Mount Vesuvius during an eruption, when stones were being hurled into the air and lava flowed nearly at his feet.

It is earnestly to be desired that the magnificent series of portraits he took of his many eminent contemporaries, and of the thousand and one places which he visited—commencing in 1868—should find a suitable resting-place in the British Museum or other national repository.

Sir Benjamin Stone was not only celebrated as a photographer; he will long be remembered as one of the most amiable and generous of men, who spared no pains nor private means to promote the welfare of all those with whom he was brought into contact, and his numberless acts of kindness have endeared him to a very wide circle of devoted friends who lament his loss. Lady Stone, his constant companion in his travels, only survived her husband three days.

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